

MAY 24 2005

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 19.May.05		3. REPORT TYPE AND DATES COVERED DISSERTATION
4. TITLE AND SUBTITLE BDA: ANGLO-AMERICAN AIR INTELLIGENCE, BOMB DAMAGE ASSESSMENT, AND THE BOMBING CAMPAIGNS AGAINST GERMANY, 1914-1945.			5. FUNDING NUMBERS	
6. AUTHOR(S) LT COL EHLERS ROBERT S JR				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) OHIO STATE UNIVERSITY			8. PERFORMING ORGANIZATION REPORT NUMBER CI04-1083	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) THE DEPARTMENT OF THE AIR FORCE AFIT/CIA, BLDG 125 2950 P STREET WPAFB OH 45433			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION AVAILABILITY STATEMENT Unlimited distribution In Accordance With AFI 35-205/AFIT Sup 1			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words)				
<p>DISTRIBUTION STATEMENT A Approved for Public Release Distribution Unlimited</p> <p>20050602 006</p>				
14. SUBJECT TERMS			15. NUMBER OF PAGES 702	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT	

BDA:
ANGLO-AMERICAN AIR INTELLIGENCE,
BOMB DAMAGE ASSESSMENT,
AND THE BOMBING CAMPAIGNS AGAINST GERMANY, 1914-1945

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
The Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

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The Ohio State University
2005

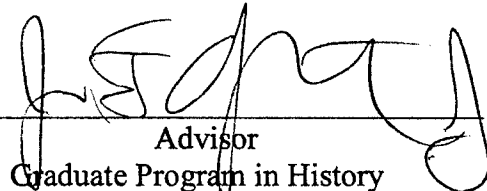
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The views expressed in this work are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or U.S. Government.

ABSTRACT

The Anglo-American bombing campaigns against Germany during the world wars relied on air intelligence for targeting information and bomb damage assessment (BDA) reports. These gave airmen key insights on the effectiveness of aerial bombardment. Air intelligence emerged as a new specialty during the Great War. By 1918, an *intellectual infrastructure* with organizational and technological components had developed in the British and American air arms. The organizational elements included air staffs with intelligence specialists assigned to provide BDA reports to senior airmen, and unit-level intelligence sections to assess the effects of individual bombing raids. The technologies included reconnaissance aircraft and cameras to collect BDA photographs on the effects of bombing raids. Although bombing and BDA capabilities remained rudimentary during the Great War, they set a precedent for World War II.

During the interwar period, despite organizational retrenchment, technological advances, especially cameras, made rapid advances. In addition, the emergence of a bombing doctrine and a four-engine bomber, the B-17, in the United States, heralded the arrival of a mature bombing capability. In Great Britain, the threat of war prompted senior leaders to begin building a new intellectual infrastructure.

Although early British bombing operations were ineffective, they allowed BDA experts at the Central Interpretation Unit, Ministry of Economic Warfare, and Research

and Experiments Division—key BDA producers—to learn their trade. The combination of this organizational infrastructure with new technologies, including reconnaissance Spitfire and Mosquito aircraft with advanced cameras, resulted in superb BDA capabilities. Once American personnel and reconnaissance aircraft began arriving in 1942, an Anglo-American intellectual infrastructure emerged.

After the Allies gained air supremacy, bombers engaged in three campaigns of decisive importance for Allied victory, first against French and Belgian railroads to isolate Normandy from German reinforcements and re-supply, then against Germany's oil industry, and finally against Germany's railroads and inland waterways. Air intelligence officers played a crucial role by giving airmen accurate insights on the effectiveness of these campaigns. The first played a vital role in the collapse of German resistance in Normandy and the Allied breakout. The second had disastrous effects on fuel production and thus on the combat power of the German military from July 1944 to VE Day. The third undermined Germany's war economy. In each campaign, BDA experts gave targeting committees the insights required to recommend the best targets for attack. The results were cataclysmic for Germany's war effort. By approaching these campaigns from an air intelligence perspective, rather than a purely operational one, this fact becomes clear.

ACKNOWLEDGMENTS


I wish to thank my adviser, Professor John F. Guilmartin, Jr., for his tireless support, superb insights, and infinite patience as I produced this work. His ethic of service, learned as a young man in very demanding circumstances, is still very much alive.

My deep thanks go as well to the other members of my committee, Professor Allan R. Millett and Professor Alan D. Beyerchen, both of whom took a good bit of time out of their very busy schedules to review this work and offer valuable insights, and to give me the basic understanding of military and European history necessary to bring this work to completion.

Special thanks go also to Colonel Thomas E. Griffith, Jr. and Professor Stephen D. Chiabotti at the School of Advanced Air and Space Studies. Professor Chiabotti gave me a great deal of encouragement throughout the Ph.D. program. His insights on bomb damage assessment as currently conceptualized and practiced by the Air Force played a vital role in my decision to make this my dissertation topic. Colonel Griffith and Professor Chiabotti also supported my dissertation research from the first, funding visits to the Air Force Historical Research Center, the Air Force Academy Special Collections Branch, The National Archives in London, the National Archives in College Park, Maryland, and the Library of Congress. They have been true champions from the outset.

Finally, I wish to thank my family for their patience and devotion as I spent many long days at the computer completing this work.

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CHAPTER 1

BOMB DAMAGE ASSESSMENT IN ITS HISTORICAL CONTEXT

*In essence, air power is targeting, targeting is intelligence,
and intelligence is analyzing the effects of air operations.¹*

- Colonel Phillip S. Meilinger, USAF, Retired

1.1 Allied Aerial Bombardment in World War II: Contrasting Views

The Anglo-American aerial bombardment of Germany formed one of the major strategic and operational chapters of the Second World War. The question of its effectiveness in supporting Allied military strategy was surrounded by controversy during the war and in the postwar period, although the majority of historians and other scholars of World War II now recognize that the Allied air forces played an important role, *in conjunction with* land and naval forces, in the defeat of the Axis powers.² However, not

¹ Colonel Phillip S. Meilinger, USAF, *10 Propositions Regarding Air Power* (Washington D.C.: Air Force History and Museums Program, 1995), 20.

² Richard Overy, for instance, has argued quite convincingly that "For all the arguments over the morality or operational effectiveness of the bombing campaigns, the air offensive was one of the decisive elements in Allied victory." He also emphasized that "There has always seemed to be something fundamentally implausible about the contention of bombing's critics that dropping almost 2.5 million tons of bombs on tautly-stretched industrial systems and war-weary urban populations would not seriously weaken them." (Richard Overy, *Why the Allies Won*, (New York: W. W. Norton & Company, 1995), 133). Overy's chapter on strategic bombing reminds us not only about the level of effort the Allies put into strategic bombing, but also that the employment of heavy bombers became increasingly effective as the Allies uncovered serious German vulnerabilities, including tenuous oil supplies and an overburdened railroad network. Williamson Murray and Allan Millett have also noted that "Strategic bombing was crucial to the Allied victory...The Combined Bomber Offensive contributed to victory because it supported, and was supported by, the efforts of Allied ground and naval forces...It was not elegant, it was not humane, but it was effective." (Williamson Murray and Allan R. Millett, *A War to Be Won* (Cambridge, MA: Belknap Press of Harvard University, 2000, 334-335). Finally, Alfred Alfred Mierzejewski and Gerhard Weinberg both emphasized the decisive importance of bombing in the destruction of the German railway network, which in turn caused the collapse of the German war economy. See Alfred C. Mierzejewski, *The Collapse of the German War Economy: Allied Air Power and the German National Railway* (Chapel Hill, NC: The University of North Carolina Press, 1988), 183-187; and Gerhard L. Weinberg, *A World at Arms: A Global*

all scholars have been willing to recognize that aerial bombardment had decisive effects on the Axis war machine in general, and on the German war effort in particular. This hesitation on the part of some scholars to ascribe any sort of decisiveness to Allied bombing has its roots in four broad causes.

The first has been a tendency in recent years to move away from a focus on bombing, and of questions surrounding its efficacy, to an examination of the ethical issues surrounding a bombing effort that was at times brutal in its application, but also one that occurred *within the context* of a global war set into motion by Adolf Hitler and carried on with incredible brutality by his German followers and their Japanese allies. Despite the fact that Allied leaders viewed bombing as an essential aspect of their effort to ensure the survival of the Western democracies by defeating the Axis powers, and therefore accepted *prima facie* the ethical implications of bombing, several recent works have engaged more heavily with the moral question than with the practical one.³

History of World War II (Cambridge: Cambridge University Press, 1994), 580. These eminent scholars have arrived at the same essential conclusion: bombing played a decisive role in the Allied victory because it was effectively integrated into grand and military strategy and therefore acted in concert with land and sea power. There is very clear evidence that the symbiosis between the different arms proved vital to the Allied cause. It also forced the Germans to divert scarce resources, including 70 percent of their fighter aircraft, to the air defense of the Reich, which cost them air superiority on the fighting fronts.

³ Michael Sherry led the field in attacking American strategic bombardment as an evil activity that effectively put the Allies and the Axis at the same level of brutality in waging the war. The crux of his argument was that, "At bottom, technological fanaticism was the product of two distinct but related phenomena: one—the will to destroy—ancient and recurrent; the other—the technical means of destruction—modern. Their convergence resulted in the evil of American bombing." Unfortunately, Sherry's grasp of the very real strategic and operational advantages derived from Allied bombing *as a means for shortening the war and saving the lives of Allied soldiers, airmen, and sailors*, was almost entirely lacking. He failed, for instance, to mention the severe and unrelenting fuel crisis brought on by the Allied air offensive against German oil production, which played a key role in shortening the war—and therefore the casualty lists. His key argument is at Michael S. Sherry, *The Rise of American Air Power: The Creation of Armageddon* (New Haven, CT: Yale University Press, 1987), 254. Ronald Schaffer provided a more effective discussion of the ethical issues surrounding Allied aerial bombardment by placing Allied decisions about bombing firmly within the context of the larger war they were fighting against a brutal enemy. American civilian and military leaders in particular expressed different reasons for allowing the precision bombardment effort to slip gradually and steadily towards one in which blind-bombing tactics (bombing through cloud cover with the first operational radar sets, which was inaccurate

The second factor has its roots in a tendency—which, happily, has become less prevalent over time—to evaluate the effects and effectiveness of bombing strictly on their own merits, rather than as part of a global war in which Allied air, ground, and naval operations were closely intertwined and symbiotic. Any evaluation of the efficacy of aerial bombardment must be placed in this larger combined-arms and combined-operations context. Recent scholarship has made great strides in this direction, particularly with respect to the role of the Combined Bomber Offensive (CBO) in destroying the German Air Force and giving Allied air forces a clear and ultimately overwhelming superiority on every fighting front. In addition, a few books have appeared that look at the disastrous effects of Allied bombing on the German war economy. Nonetheless, these books represent only a start in the right direction, and they fall short in their treatment of the role of Allied air intelligence, particularly bomb damage assessment (BDA), in the defeat of Germany.⁴

and caused additional German civilian casualties, yet still put enough bombs on target to achieve objectives) became prevalent in the winter of 1944-45. However, all agreed that Germany had to be defeated as quickly and decisively as possible, and that bombing was one means for accomplishing that end. See Ronald Schaffer, *Wings of Judgment: American Bombing in World War II* (Oxford: Oxford University Press, 1985), 103-106. Conrad Crane agreed with Schaffer's view that, despite American airmen's reluctance to move from precision bombing towards area bombing, they did so nonetheless for both pragmatic and psychological reasons, arguing that if blind-bombing tactics were the only option during the winter of 1944-45, they were therefore appropriate given their ability to assist in shortening both the duration of the war and Allied casualty lists. His argument is in Conrad C. Crane, *Bombs, Cities, and Civilians* (Lawrence, KS: University of Kansas Press, 1993), 115-118. Finally, Stephen Garrett addressed the moral issues surrounding the British area city bombing campaign, noting that it failed the test of ethics and morality, particularly late in the war, when British survival was no longer threatened and the Allied victory imminent. See Stephen A. Garrett, *Ethics and Airpower in World War II: The British Bombing of German Cities* (New York: St. Martin's Press, 1993), xi-xvi, 180-181.

⁴ General Omar N. Bradley recognized the symbiosis between air, land, and naval forces, and also made clear his view—which was shared by the vast majority of Allied ground, air, and naval commanders—that airpower was not decisive in its own right, when he stated that “It is considered most significant for the course of the war that American military authorities consistently held the opinion that air attack was not of itself sufficient [to defeat Germany], and that air forces were only part of a rounded team.” This is an important point to keep in mind while reading this and indeed any other scholarly work on Allied air operations during the Second World War. See RG243, E36, B191, General Omar N. Bradley and Air Effects Committee, 12th Army Group, *Effect of Air Power on Military Operations: Western Europe*, 15 July

A brief mention of one vital but largely overlooked symbiosis between air and ground forces demonstrates how far we have to go, as a scholarly community, in drawing these connections more clearly. The oil offensive waged by Allied bombers against Ploesti, German synthetic oil plants, and the German crude oil industry from April 1944 until VE Day starved the Germans of fuel not only on the Western Front, but even more so on the crucial Eastern Front. This vital contribution has gone largely unmentioned in earlier scholarship. The point here is not that bombing somehow accomplished this single-handedly, or that every German tank and truck came to a complete standstill as a result of the oil offensive. It would have been a physical impossibility to achieve such effects, and we know from the many works of history written about the ground war that until 1945 the Germans usually came up with enough gas to meet their immediate needs. But they did not do so every time, especially in the East. Indeed, if we view the results of the oil offensive *in conjunction with* the nearly unbroken string of Russian offensives from June 1944 to VE Day, which gave the Germans no respite and forced them into huge battles of maneuver that consumed prodigious quantities of fuel, we begin to see more clearly how one influenced the other. This topic will receive detailed attention later, but the important thing to recognize here is that air intelligence personnel and their commanders understood what an offensive against oil might accomplish, not just in the service of the Allied air effort, or of the Western Allies' larger war effort, but rather in

1945, 1. Air Chief Marshal Lord Tedder echoed Bradley in his assertion that "In my view, air power...is interlocked with sea and land power, and all three are interdependent." See Lord Tedder, *Air Power in War* (London: Hodder and Stoughton, 1948), 29-32. We have already seen that Overy, and Millett and Murray, hold the same view.

terms of its *overall* impact on the Allied—including the Russian—and German war efforts, and how it might in this sense contribute to a quicker and less costly victory.⁵

The third factor clouding the issue of bombing's effects and effectiveness has been the tendency among scholars to lump all Allied bombing together under the rubric of the CBO. However, as John Guilmartin notes, there were in fact *several* campaigns. These included Bomber Command's area bombing of German cities; the USAAF's Unescorted Daylight Strategic Bombardment Campaign of 1943; Operation ARGUMENT, the USAAF effort in February 1944 that compelled the Luftwaffe fighter force to accept battle and, ultimately, defeat; the three transportation offensives from 1943 to 1945 against Axis railroad and inland waterway traffic, first in Italy, then in France and Belgium, and finally in Germany itself; and the oil offensive of 1944-45. Even more important is the fact that there were several British bombing campaigns early in the war,

⁵ To provide just one example of many to follow in later chapters, General Carl Spaatz, Commander of United States Strategic Air Forces in Europe (USSTAF), pushed hard for an oil offensive because, as he put it, "Oil attacks will weaken German Army and GAF on all fronts simultaneously, including the all-important Eastern front." His comments are in AIR 37/1125, HQ USSTAF, Proposal to Supreme Headquarters Allied Expeditionary Force (SHAEF), "Employment of Strategic Air Forces in the Support of Overlord," 3. Of equal significance was the great importance the Russians placed on attacks against oil targets. Major General John R. Deane, head of the U.S. Military Mission in Moscow, told Spaatz that, "In pressing the Russians to find out what targets they would like to have hit, they have indicated that they would like a continuance against Bucharest [and] Ploesti...In our conversation the fact was brought out that the Russians considered the oil in Ploesti as being a primary objective." The Russians clearly knew that over half of the gasoline produced at the Ploesti refineries was going directly to the Eastern Front, and they sought Allied assistance in reducing or stopping those deliveries. These comments are in MS 16, S3, B4, F1, Cable, Deane to Spaatz, 10 May 1944. Similarly, during a visit to Russia by a delegation of USSTAF senior officers, General Vladimir Grendal, chief of Red Army intelligence, emphasized that oil was the most important target system for Allied heavy bombers to attack. See Spaatz Box 17, "Report on Visit to Russia by Mission of USSTAF Officers, Appendix B, Conference with Gen Grendal, 13 May 1944, 21 May 1944. Allied air leaders understood the importance of such attacks and made them an integral part of their air strategy. Once the oil offensive began, Allied air commanders clearly understood, from BDA reports, that bombing was causing huge reductions in German oil production, and that as such the oil offensive was creating increasingly severe and widespread oil shortages in the German military, which in turn was having a disastrous impact on the Luftwaffe's ability to operate and on the German army's ability to engage in the huge battles of maneuver that began in June 1944 and continued almost without letup until V-E Day. See MS16, S5, B8, F7, "Joint Oil Target Committee, Working Committee, Weekly Bulletin No. 15," 10 Oct 1944, 1, which assessed German production of finished petroleum, oil, and lubricants (POL) products—correctly as German records later confirmed—to be 23.5% of the pre-attack total.

including Bomber Command's anti-invasion campaign of 1940-41 against German-controlled port facilities and barges along the English Channel, an abortive oil offensive against German synthetic oil plants and crude oil refineries in western Germany during the same period, which failed for lack of bombers, navigational skills, and accurate bombsights and bombing techniques, and early British night bombing in 1941-42.⁶

The crucial link between these disparate air campaigns, from the standpoint of targeting and BDA, was the iterative learning process that occurred as air intelligence personnel recommended targets to their commanders and then assessed the effectiveness of bombing raids against them. In the process, they honed their analytical skills while providing increasingly accurate BDA to senior air commanders, who in turn employed it to steer their ever-larger bomber forces against the most lucrative German target sets. This process was gradual and involved many errors in target selection, BDA analysis, and judgments about the effects and effectiveness of bombing raids and campaigns, which in turn resulted in operational errors as bombers either attacked target sets that were not particularly lucrative, attacked too many different kinds of targets simultaneously with inadequate forces, or failed, as in the case of attacks on German ball bearing production, to attack lucrative target sets often enough. Despite these errors, Allied air intelligence personnel got steadily better at their jobs as the war progressed. By the spring of 1944, their experience and hard work resulted in the emergence of superb Anglo-American targeting and BDA capabilities. These allowed air intelligence officers to recommend the

⁶ John F. Guilmartin, Jr., unpublished manuscript, "The Aircraft that Decided World War II: Aeronautical Engineering and Grand Strategy, 1933-1945, The American Dimension," expanded version, USAF Academy 2001, Harmon Memorial Lecture, 2-3.

most lucrative target sets, including oil and transportation, to senior airmen, and then to track, with great precision, the effects of Allied bombing raids on those target sets.

The fourth factor that has made scholars shy away from engaging in any serious attempt to assess the decisiveness of Allied bombing has to do with the fact that the overwhelming majority of books and scholarly articles written about the CBO have come at the problem from an operator's perspective. Many of the books in this sub-genre are outstanding, but they tend not to grapple sufficiently with the larger question of assessing the effectiveness of Allied bombing. They also ignore the huge planning and intelligence efforts that went into directing their operational employment.

1.2 The Role of Air Intelligence in the Planning and Direction of Allied Bombing

The last of these other key functions—directing the bombing effort—is a primary concern of this work. The analytical tools that allowed Allied air commanders to provide this direction, including targeting, BDA, and munitions effectiveness assessment (MEA), are at the center of the narrative. So are the hundreds of men and women who brought these skills to a peak of effectiveness not since equaled even in the age of jet aircraft, reconnaissance satellites, cruise missiles, and “smart” bombs.⁷ These largely overlooked air intelligence personnel, who assessed the effects of bombing on the Nazi war machine and, based on those assessments, advised their commanders on the most effective use of heavy bombers, played a vital role in speeding the victory over Germany. This story is in large part theirs, and we owe them a debt of gratitude not yet paid in existing studies of the Allied bombing effort. In fact, only three chapters in a single book have even begun

⁷ Although this work focuses predominantly on BDA, it is impossible to do so without also discussing targeting and Munitions Effectiveness Assessment (MEA) in some detail. Analysis of the effects and effectiveness of Allied bombing campaigns will therefore begin with an overview of the targeting rationale and methodology for each campaign and will include MEA data.

to weave together the ways in which BDA experts employed their sources and methods, comprised largely but not entirely of reconnaissance photos, to advise commanders on the optimum employment of bombers. Only a handful of other books discuss this effort in more than a cursory fashion, and none of them makes clear the close ties between air intelligence personnel and the commanders who directed the bombing effort. This represents a key oversight on the part of scholars, which this work seeks to correct.⁸

The importance of recognizing these contributions of air intelligence personnel to the Allied victory by making clear the value of the BDA work they did, and by examining the advice they gave their commanders about the employment of bomber forces, is great because these individuals are largely absent from the historical record, and because the BDA effort they orchestrated played a central role in the air war by enabling commanders to steer their bombers to the most lucrative target sets. Of these, the two most important were German transportation assets in occupied Europe and the Reich itself—including railroads, inland waterways, and motor transport—and oil assets, which included both crude oil refineries and more importantly the huge synthetic oil and fuel production plants built in Germany during the 1930s and early 1940s. From the spring of 1944 to

⁸ See Chapters 2-4 in John F. Kreis, General Editor, *Piercing the Fog: Intelligence and Army Air Forces Operations in World War II* (Washington D.C.: Air Force History and Museums Program, 1996), 57-246. F. H. Hinsley et al, *British Intelligence in the Second World War* (London: Her Majesty's Stationery Office, five volumes, 1979-1990), provides a very detailed look at British intelligence efforts, including a reasonable amount of information on air intelligence activities. Constance Babington Smith's classic work, *Evidence in Camera: The Story of Photographic Intelligence in the Second World War* (Phoenix Mill, U.K.: Sutton Publishing Limited, 2004), tells the story of British photointerpreters at the Central Interpretation Unit (Allied Central Interpretation Unit once the Americans arrived) and their vital role in the Allied victory. A less well-known but equally good book on the same subject is Ursula Powys-Lybbe, *The Eye of Intelligence* (London: William Kimber, 1983). Roy M. Stanley's *World War II Photographic Intelligence* (New York: Charles Scribner's Sons, 1981) is the best single work on this important BDA-related subject. Roy Conyers Nesbit's *Eyes of the RAF: A History of Photo-Reconnaissance* (Phoenix Mill, UK: Alan Sutton Publishing Ltd., 1996) provides a useful overview of RAF photoreconnaissance from World War I to the present. Several other books in this genre will appear as footnotes later in the text and in the bibliography.

VE Day, air intelligence experts convinced their commanders to stay focused on these target sets. The results were decisive when viewed in combination with the Allied ground effort, which profited greatly from these bombing efforts. The transportation and oil campaigns not only starved the Germans of fuel, ammunition, and other supplies, but also made it impossible for them to mass, maneuver, and counterattack on a large scale.

The first of three major transportation offensives focused on the Italian railroad network in an effort to hamper the movement and re-supply of German ground forces. Because Italy is a relatively narrow peninsula bisected by mountains, and because the German effort there was almost entirely defensive, this campaign was not highly successful, but it did place a significant strain on German military operations in Italy. The second transportation offensive, against railroad marshalling yards in France and Belgium, resulted in the near-complete collapse of German operational and tactical mobility in the West, and of the Wehrmacht's ability to provide adequate logistical support to the troops at the front. At the same time, the oil offensive, carried out with a single-minded focus and sense of purpose that are palpable even today in the primary sources, gradually starved the German Army of fuel and therefore of operational and tactical mobility everywhere, but above all on the Eastern Front. It also had an immediate and catastrophic effect on Luftwaffe operations and pilot training. Finally, the third transportation offensive, against the railroads and inland waterways of the Reich, caused the collapse of the German war economy in the early spring of 1945, and worked in combination with the oil offensive to starve German troops at the fighting fronts of fuel along with ammunition, spare parts, and virtually every other necessity of war.

To say that the BDA effort carried on by air intelligence personnel played a central role in these successes is no exaggeration. By 1944, and to a lesser extent as early as 1942, the Allies had a highly capable and integrated network of intelligence organizations in place to advise commanders on target selection and give them accurate appraisals of the effectiveness of bombing raids against those targets. Their commanders listened to them and, with very few exceptions, put their recommendations into practice in the guise of the various campaigns that came under the larger umbrella of the CBO. In fact, it was no accident that a highly effective air intelligence function, based largely on the superb reconnaissance and photointerpretation capabilities pioneered by the British between 1939 and 1942, allowed an expert BDA capability to emerge over two years *before* RAF Bomber Command and the United States Strategic Air Forces in Europe (USSTAF) had enough bombers to do really serious and lasting damage to the German war effort. By the time they did, in the spring of 1944, the targeting and BDA capabilities were in place to allow air commanders to steer their bombers to vital transportation and oil targets, the destruction of which shortened the war by at least several months and shortened Allied casualty lists—especially those of the Russians—considerably.

The military and civilian air intelligence organizations that supplied the BDA at the root of these operational and strategic successes had a remarkable dualism in the sense that they were in many ways *ad hoc* structures, created shortly before or during the war and often under the most trying circumstances, to fulfill specific functions, but also benefited immensely from a unique Anglo-American capability to organize the war effort for maximum efficiency and effectiveness. This ability to organize for war was deeply rooted in the rationalist, scientific, and bureaucratic-administrative traditions of the West.

Even a cursory look at Allied air intelligence in the Second World War reminds us that the Anglo-Saxon democracies were particularly adept at organizing their war effort. They sought to maximize organizational efficiencies in order to increase their military effectiveness. This was absolutely the case for Allied air intelligence organizations, including those responsible for targeting and BDA. This organizational efficiency was built on an *intellectual infrastructure* that included highly trained intelligence professionals; the world's best reconnaissance technologies, including specially-modified Spitfire and Mosquito aircraft, advanced cameras, and precision photointerpretation instruments; and above all experience and an ability to make the right bombing recommendations, which came from an increasingly deep knowledge of the Axis foe. It gave intelligence personnel the tools and analytical insights necessary to pick target sets most likely to cause maximum damage and disorganization to the German war effort. Even more important, it allowed them to monitor, with almost machine-like precision, the effects of strategic bombing on key target sets such as oil and transportation, and then to recommend changes in targeting priorities based on meticulous BDA reports. In the process, they helped to ensure that Allied bombing would do grievous damage to the German war effort. Air intelligence bodies such as the Combined Strategic Targets Committee allowed commanders to wage the oil and transportation offensives against the Reich on a one-week cycle that anyone familiar with the American-NATO Air Tasking Order (ATO) process would recognize immediately.

1.3 Western Rationalism, the Scientific Method, Air Intelligence, and BDA

The BDA experts at the center of this story, men and women alike (nearly half of the British photointerpreters were in the Women's Auxiliary Air Force), and the commanders

they supported, were the product of more than two centuries of intellectual, academic, and scientific development unique to the West, and more particularly to Great Britain and the United States. They were educated in the rationalist and scientific tradition that had its origins in the writings of such great thinkers as Isaac Newton, John Locke, and Adam Smith, and that tradition, however consciously or unconsciously, guided the manner in which they produced the air intelligence that proved vital to winning the war.⁹ Indeed, one can detect the Scientific Method at work in virtually every aspect of the Allied war effort, and this is nowhere truer than in the case of targeting and BDA efforts. General Carl Spaatz, Commander of United States Strategic Air Forces in Europe, wrote a memo at the end of the war in Europe commending the efforts of the Combined Strategic Targets Committee (CSTC). He closed with the assertion that "The brilliant work and infinite pains which these organizations [the CSTC and its four working groups, which focused on oil, transportation, the Luftwaffe, and armored fighting vehicles] have shown in piecing together the multiplicity of intelligence information, have raised the selection of strategic targets to the stature of a science."¹⁰ Air Commodore Sydney Bufton and Brigadier General Alfred ("Fred") Maxwell, Co-Chairmen of the CSTC, echoed Spaatz when they said at the CSTC's final meeting that "it was not too much to say that the

⁹ William McNeill has traced these developments skillfully in *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000* (Chicago, IL: University of Chicago Press, 1982). In *The Cultural Meaning of the Scientific Revolution* (New York: Alfred A. Knopf, Inc., 1988), Margaret Jacob traced the development of Western science and rationalism, making the crucial point that a combination of Cartesian and Newtonian reasoning, religious tolerance, and early capitalist economic developments in England between 1700 and 1750, created a unique environment in which rationalism and science advanced hand-in-hand. In *The Rise of the Western World: A New Economic History* (Cambridge: Cambridge University Press, 1973), Douglass C. North and Robert Paul Thomas emphasize the vital role of economic efficiency in propelling the West to unrivalled wealth and power. In this sense, their work builds on insights put forth by Adam Smith in *The Wealth of Nations*. These books, when read together, provide an excellent overview of the major contextual factors—rationalism, science, efficiency, and effectiveness—at the heart of the Allied war effort writ large, including the development of BDA capabilities.

¹⁰ AIR 2/8011, Memo, Spaatz to CSTC, May 1945 (no specific date on memo, but probably 8-10 May).

Working Committee had taken the whole question of target selection for the Allied Strategic Air Forces from the stage of guesswork to that of Scientific Method.”¹¹

Both the British and the Americans employed large Operational Research Sections, and these organizations provided a great deal of valuable statistical information on the effects of Allied bombing. The fact that senior airmen acted on nearly all of their recommendations to increase the effectiveness of the bombing effort only underscores the degree to which Western rationality guided the various bombing campaigns.¹²

It will become clear in this work that such views were fundamental to the way in which the Allies organized their entire war effort, whether on the battlefield or in the offices of the intelligence organizations. A number of prominent scholars have noted this fact, including Richard Overy, who was the first to point out how effectively the Allied air effort leveraged human talent, organizational innovation, engineering prowess, and technological development, bringing airmen and their civilian counterparts together in what proved to be a highly efficient, effective, and harmonious relationship—one that was just as clearly lacking in the Axis air effort, as Overy, Williamson Murray, and David Kahn have made abundantly clear in several of their works.¹³

¹¹ AIR 2/8011, “Combined Strategic Targets Committee, Minutes of the 28th Meeting, Held in Air Ministry, Whitehall, on Wednesday, 2nd May, 1945,” Appendix C, “Appreciation of the Joint Chairmen of the C.S.T.C. of the Work of the Members of the C.S.T. Committee,” 11 May 1945.

¹² See Air Ministry, *Operational Research in the RAF* (London: Her Majesty’s Stationery Office, 1963) and Charles W. McArthur, *Operations Analysis in the U.S. Army Eighth Air Force in World War II*, History of Mathematics Series, Vol. 4, (Providence, RI: American Mathematical Society and London Mathematical Society, 1990). Additional references to these books, addressing OR/OA studies carried out in support of Allied bombing, appear in subsequent chapters.

¹³ Richard Overy was the first to address this issue with respect to Allied air operations in *The Air War: 1939-1945* (Briarcliff Manor, NY: Stein and Day, 1981), 191-260, which is still the best general work available on the air war. See Chapter 7, “The Aircraft Economies,” and Chapter 8, “Science, Research and Intelligence.” In the former, Overy noted that much more efficient and effective Allied production techniques, employment of skilled labor, and organization of the aircraft factory system; more rapid introduction of new generations of improved combat aircraft; and better research, development, testing, and

This Allied advantage was nowhere clearer than in the intelligence effort. In fact, the agencies responsible for producing BDA reports took full advantage of the best human talent and employed it in ways that were highly efficient and effective. Once again, the Allied advantage in this arena was substantial and proved vital to the success of the Allied war effort, just as poor German intelligence capabilities—and indeed the shocking lack of interest most German commanders showed in operational and strategic intelligence—helped to undermine the Axis war effort. German air intelligence failures, of which there were many, stand in stark contrast to Allied successes, which are finally receiving attention in a growing body of scholarship.

The British and their American allies employed their intelligence talents—born of their deep immersion in the rationalism and science of the West—in ways both vital and

evaluation (RDT&E) techniques all benefited the Allies tremendously. The Axis effort, by contrast, lacked clear or centralized direction and involved a multiplicity of competing weapons-development programs that came in and out of favor, sometimes several times, depending on the Führer's proclivities, which became more erratic and changeable as the war progressed. In the latter, he demonstrated how much more effectively the Allies harnessed scientific talent, the most efficient research processes, and superb scientific, technical, and operational intelligence to their larger war effort as well as the air war. Williamson Murray illustrates that the opposite was true of the Luftwaffe from its inception to its defeat in the skies over the Reich. In *Strategy for Defeat: The Luftwaffe 1933-1945* (Maxwell AFB, AL: Air University Press, 1983), 12-14 and 96-99, he noted that the Germans failed to design and produce new generations of aircraft and had a hopelessly chaotic design and production process in which the Germans failed to make good use of their human—and particularly organizational and scientific—talents. In *Hitler's Spies: German Military Intelligence in World War II* (New York: Da Capo Press, 1978), 524-541, David Kahn argued cogently that several factors rendered the German intelligence effort largely ineffective, including an unjustified arrogance in the early years of the war that made the Germans unwilling—and perhaps psychologically unable—to develop an effective intelligence capability. He also noted that for a variety of reasons, most German senior officers were hostile towards intelligence officers and tended to assign intelligence duties to their least capable subordinates. Finally, he stated that the authoritarian structure of the Nazi state (and, similarly, the ways in which its systems of authority were structured) seriously impaired its ability to collect, analyze, and disseminate intelligence in an effective fashion. The unrelieved series of disastrous failures in German intelligence, beginning with the Battle of Britain, continuing with the Russian campaign, and culminating in the utter inability to determine where and when the main Allied landings in France would occur, bear out Kahn's arguments. Kahn also emphasized that the Führer himself was increasingly unwilling to accept any intelligence containing bad news. The Allied ability to read Enigma messages also proved crucial to the BDA effort because these intercepts provided a wealth of near-real-time insights on the effects of Allied bombing. The best sources for this process include Ronald Lewin, *Ultra Goes to War* (New York: McGraw Hill, 1978) and Kreis, General Editor, *Piercing the Fog*.

fundamental to Allied victory. Although Carl von Clausewitz warns us that war is neither science nor art, Allied air intelligence personnel brought an abundance of both to the war effort, melding them together in what can only be termed the greatest intelligence effort, and the greatest intelligence success, in the history of warfare. This ability to meld the qualities of rationality and the Scientific Revolution gave air intelligence specialists a unique mindset that allowed them to wage war with a high degree of efficiency and operational effectiveness. When this was combined with the unparalleled Allied ability to wage total and industrialized war on a global scale—to conduct “machine war,” as a number of scholars have called it—the result was an air effort and a series of bombing campaigns that were effective, focused, and above all relentless in their character. John Keegan, in discussing the American air effort in the Second World War, said

There is an American mystery, the nature of which I can only begin to perceive...If I were obliged to define it, I would say it is the ethos—masculine, pervasive, unrelenting—of work as an end in itself. War is a form of work, and Americans make war, however reluctantly, however unwillingly, in a particularly workmanlike way.¹⁴

This workmanlike way of war involved leveraging the rationalist, scientific, and managerial talents developed in the West from the end of the seventeenth century to the middle of the twentieth. Indeed, Keegan’s comments about American warmaking apply with equal force to the British air intelligence effort in World War II, which was utterly rationalist and highly effective. Indeed, in this arena, it was the British who were the teachers, the Americans their pupils. The work of British intelligence specialists in the Air Ministry; Central Interpretation Unit (renamed the Allied Central Interpretation Unit once large numbers of Americans began arriving in 1943); Research and Experiments

¹⁴ John Keegan, “The View from Kitty Hawk,” *Military History Quarterly*, VIII:3, 13.

Department Eight (initially under the Ministry of Home Security and later the Air Ministry); Ministry of Economic Warfare; Railway Research Service; and a host of other agencies made this clear. They did so not only with their very accurate BDA, but also as they taught the Americans how to do their jobs most effectively by bringing together and leveraging the skills and deep knowledge of all the BDA experts involved in this effort.

1.4 Key Attributes and Results of Allied BDA

The vital attribute that Allied BDA brought to bear was an ability to make reasoned and accurate judgments about airpower's effectiveness in hampering the German war effort. This ability increased as the war continued, driven by a closer and more effective cooperation between British and American air intelligence organizations. Viewed in the deeper historical context of Western rationalism, science, and creative thought, the BDA effort for Allied bombing proved remarkably effective. It was not perfect by any means, and was sometimes hampered by errors in analysis and judgment, but it succeeded. The great strength of the Allied air intelligence community was its ability to bring together and orchestrate all aspects of BDA within an intellectual infrastructure of the highest order—one that drew on the inherent organizational, technological, and human strengths of the Western democracies. This intellectual infrastructure proved able to gauge, with great precision, the *accuracy* of bombing, its *effects* on Germany's war effort, and its *effectiveness* in helping the Allies to achieve their war objectives.¹⁵

¹⁵ These are the three fundamental attributes of BDA. Accuracy relates to how close to a target an aircraft places its weapons, effects are the various kinds of damage done to the target, and effectiveness—by far the most important of the three—is the degree to which a given bombing raid or campaign contributes to the attacker's military strategy and hampers that of the enemy. BDA was and still is closely associated with Munitions Effectiveness Assessment (MEA), which assesses how effectively a given weapon functioned against a particular target. The RAF's Operational Research and USAAF's Operations Analysis efforts were focused in part on this question of maximizing weapons effects. American doctrine currently places

Perhaps the thing that Allied BDA made most clear about the series of heavy-bomber campaigns known collectively as the Combined Bomber Offensive (CBO) was the steadily increasing and ultimately pervasive friction, in the Clausewitzian sense of the word, which it created in the German war effort. By the spring of 1944 this friction was everywhere in evidence. From the increasingly severe fuel shortages in both the Luftwaffe and the German army; to the constant delays, equipment losses, and casualties German troops experienced in conducting tactical maneuvers as well as movements to or between the various fighting fronts; to the ammunition shortages of the war's final months; and in a myriad of other ways, Allied airpower, including heavy bombers, proved to be the creator of friction in the Nazi war machine *par excellence*. It was everywhere at work, making even simple tasks difficult or impossible. Clausewitz's description of friction is particularly well suited to describing the effects of air attack on the Wehrmacht. In war, Clausewitz said, "Friction is the only concept that more or less corresponds to the factors that distinguish real war from war on paper...Action in war is like movement in a resistant element. Just as the simplest and most natural of movements, walking, cannot easily be performed in water, so in war it is difficult for normal efforts to achieve even moderate results."¹⁶ For the Germans after the spring of 1944, the resistant element was increasingly like molasses rather than water.¹⁷

these two activities, BDA and MEA, together under the larger category of Combat Assessment, but they will appear in their World War II format—BDA and MEA—in this work.

¹⁶ Carl von Clausewitz, *On War*, edited and translated by Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1989), 119-120.

¹⁷ It is important to note that Allied senior airmen's perceptions of the friction caused by bombing, which were strikingly Clausewitzian, probably did not come from a deep knowledge of Clausewitz's writings. There were a few lectures at the Air Corps Tactical School during the 1930s in which Clausewitz's ideas appeared very briefly, and he was known to British senior officers as well, but it appears as though the effects of Allied bombing on the German war effort, though Clausewitzian in practice and intended to be so, were probably not inspired by a deep knowledge of Clausewitz's statements about friction in *On War*.

The Germans, despite their extraordinary repair efforts, fell further and further behind in the desperate and ultimately hopeless race to counter the disastrous effects of the friction caused by air operations in virtually every facet of their war effort. Tactical movements that took a few days while the Germans owned the skies over Europe, often took two weeks or more to complete once the railroads, marshalling yards, inland waterways, and road and railroad bridges of western and central Europe came under concerted air attack. As they arrived at the fighting fronts, German troops often discovered that Allied bombing had created serious fuel shortages, making the *Kampfgruppe*-level tactical maneuvers at which they excelled impossible. The civilian managers of the *Reichsbahn* and their counterparts who ran Germany's synthetic oil plants worked under increasingly nightmarish conditions, trying to carry out basic functions—moving soldiers, ammunition, and coal by rail on the one hand, and producing aviation and motor fuel on the other—while at the same time having to devote huge numbers of workers and resources to repair the increasingly severe damage caused by Allied bombers. Albert Speer noted after the war that between 200,000 and 300,000 laborers were engaged full time in the effort to repair synthetic oil plants, and even this huge level of effort proved inadequate.¹⁸ The Germans were resourceful adversaries, but in the end they could not keep up with the increasing tempo of Allied bombing and the friction it created, which inexorably overwhelmed German efforts at the fighting fronts, in the railway centers, at the oil plants, and virtually everywhere else. And throughout this process, which gained momentum and matured during the spring and summer of

¹⁸ AIR 20/8779, Supreme Headquarters Allied Expeditionary Force, Office of Assistant Chief of Staff, Intelligence (SHAEF G-2), "Interrogation of Albert Speer, former Reich Minister of Armaments and War Production, 6th Session, 1500-1700 hrs., 30th May 1945," 3.

1944, Anglo-American air intelligence organizations provided the BDA that allowed senior airmen to steer bombers to the most lucrative targets skillfully and to great effect.

1.5 Allied Bombing, BDA, and Combined Operations

The friction caused by Allied strategic bombing played a decisive role in the Allied victory, but it is important to emphasize that it did not do so alone. Strategic bombing never became the war-winning instrument envisioned in the writings of Douhet, Trenchard, and Mitchell or in the initial bombing policies of General Ira Eaker and Air Chief Marshal Arthur Harris. It helped to win the war *in combination with* soldiers on the ground, whose role was in many ways the most fundamental in the Allied victory, and also with the sailors and merchant mariners who braved the perils of the Atlantic Ocean to keep the supply and replacement pipelines open from the United States to Great Britain and the Soviet Union. In fact, it was the growing Allied expertise in planning and executing combined operations during the last two years of the war that allowed heavy bombers to play an increasingly vital role not only at the military-strategic level, but also in operational and tactical engagements by starving the Germans of fuel, transport, and ammunition, and by providing direct support to ground forces, particularly in the opening stages of major Allied breakthroughs in Normandy and western Germany.

Russell Hart and Christopher Duffy have coined similar phrases to describe what happened to the German Army on the Western and Eastern Fronts as a result of the pervasive fuel shortages brought on by bombing: demotorization and dемеchanization.¹⁹ In short, the Germans were forced to send the trucks assigned to Panzer and Panzer

¹⁹ Russell A. Hart, "Feeding Mars: The Role of Logistics in the German Defeat in Normandy, 1944," *War in History* 1996 3 (4), 418-435; Christopher Duffy, *Red Storm on the Reich: the Battle before Berlin* (London: Routledge, 1991), 48-50.

Grenadier divisions, which were supposed to move German soldiers quickly from one spot to the next, to forage for fuel and ammunition instead, often at night and over great distances, in order to provide German armored and motorized vehicles and German artillery with at least the bare minimum of tactical maneuver and firepower capabilities. The bare minimum was in most cases all they received, with predictable results: an inability to engage in maneuver warfare over any significant distance. This problem, as disastrous as it was on the Western Front, proved cataclysmic in the East, particularly once the Red Army perfected its deep penetrations and encirclements of German units, which often lacked the fuel to counterattack vigorously or even to regroup. Allied BDA specialists played a vital role in these developments because they very quickly saw the major consequences to the Germans of the Allied bombing effort against German oil and fuel production and supplies, resulting in a high priority for oil targets—and increasingly severe fuel shortages for the Germans—from May 1944 until the end of the war.²⁰

There is also some evidence to indicate that the German military, unlike German civilians, proved unwilling and unable to adjust effectively to the increasingly heavy Allied bombing effort. While *Reichsbahn* officials and synthetic oil plant managers proved adept at repairing damage caused by bombing, the German Army held doggedly to its doctrinal and ideological assumptions about how the war should be fought at the

²⁰ Allied air intelligence organizations had known all along about the tenuous German fuel position, but operational commanders had too few heavy bombers and lacked air superiority over the Reich until spring 1944. Once the oil offensive started, Ultra intercepts quickly confirmed that the Germans, already short of fuel, regarded the attacks with alarm. Within three weeks the Luftwaffe was already imposing severe restrictions on training flights and all other non-combat sorties. On 5 June 1944, Göring sent a message to all Luftwaffe senior officers directing that “extreme measures on economy” be taken regarding all non-combat flying, including pilot training, and ordering his subordinates to be “absolutely ruthless” in their application. Aerial photographs and Ultra also corroborated one another very effectively, making clear the looming German fuel catastrophe. See AIR 40/2073, AI3(e), “M.S.S. References to Oil Shortages and Restrictions since May 1944,” 30 December 1944, and Chapter 10 for a detailed discussion of these issues.

tactical level. As a result, they failed to decentralize their fuel and ammunition depots until late in the war—and never to any appreciable degree on the Eastern Front—and even then kept them far too distant from the front lines, a problem that proved particularly disastrous in the East. This in turn forced the Germans to demotorize their divisions by sending the vast majority of their trucks to locate and bring back fuel, assuming they could find any at all, which had obvious and negative tactical implications for German armored and mechanized formations. There is no indication the Germans ever made any sustained efforts to address these serious problems. The consequences, in innumerable tactical engagements, were severe fuel shortages resulting in inferior mobility and, once any kind of major retreat began, the unnecessary loss of vehicles and guns on a massive scale as German military formations ran out of gas and were forced to abandon or destroy their vehicles. Hitler's no-retreat orders, also driven by ideological concerns (the "I will not leave the Volga!" syndrome, to paraphrase one of his most impassioned declarations to his military staff in November 1942), made fuel shortages on the vital Eastern Front even more serious because they forced German armored units to fight much further forward than made sense. This proved disastrous given the Soviet tendency to make deep and relatively narrow penetrations into the German rear areas, which made it difficult or impossible for German armored formations, still fighting on the front lines by order of the Führer and cut off from their fuel depots, to replenish their fuel supplies. Assuming that German units survived at all, they did so in most cases with very little heavy equipment, much of which was immobilized by lack of fuel. This doctrinal and command inflexibility interacted with the expert maneuver warfare practiced by the Red Army during the last two years of the war, which often allowed Soviet armored

spearheads to overrun German fuel depots rapidly once they achieved a breakthrough, and with the Allied oil offensive, which by fall 1944 had reduced fuel deliveries to forward fuel depots, and from there to the front lines, to a trickle. This meant that even in the relatively rare instances where German heavy divisions on the Eastern Front (and to a slightly lesser degree on the Western Front) were in a position to replenish their fuel stocks, there was often no fuel available where and when they needed it.²¹

In addition, as Alfred Mierzejewski has demonstrated, bombers assisted the ground and naval efforts by causing the collapse of the German rail and canal networks, and thus the German war economy, from fall 1944 to spring 1945. This translated into fewer and fewer weapons and, most serious of all, less and less fuel and ammunition at the front.²²

²¹ For instance, RG243, E36, B187, CSDIC(UK), "A Survey of the Supply System of the German Army 1939-45," 25 Aug 1945, 6-7, notes that the German military supply system had no centralized control until December 1944, far too late to address the problem. Large fuel and ammunition depots resided at the field army level, which meant these supplies were 60 miles behind the front—too far back to provide rapid re-supply during sustained periods of large-scale maneuver warfare. Divisions were only allowed as many supplies as their assigned trucks and other vehicles could carry with them, which meant in practice that front-line units often had only one or two fuel increments with them at the front. A fuel increment was the amount of fuel needed to move a division-sized unit 100 kilometers (62 miles), but the calculation was based on movement over dry roads of good quality. Of course, no such roads existed in the East and were also somewhat scarce in Normandy, so in practice German units could travel about 60 miles over open and dry terrain. However, muddy roads and terrain tripled fuel use in armored vehicles and perhaps doubled it for trucks. In such conditions, a fuel increment could move a heavy division perhaps 25 miles. This meant most units in the summer and fall of 1944 had very limited mobility even in dry conditions, which meant that fighting as far forward as the Führer demanded made it unlikely that German heavy units could reach the army-level depots 60 miles distant, assuming the depots had not already been overrun by the Red Army's armored spearheads. Although the Germans decentralized their fuel depots in the West in response to the threat posed by Allied aircraft, they never did so in the East, and that proved disastrous. This disaster assumed the proportions of a cataclysm when the oil offensive began to make gasoline scarce even at the army-level depots, and when the Russians surprised the Germans by launching a major offensive in January 1945, hard on the heels of their summer and fall 1944 successes. In combination with the severe shortages brought on by the oil offensive, this unpleasant surprise caught German heavy divisions with two fuel increments at the very most, and more often with one. The road and countryside also happened to be very muddy in early 1945, which again tripled German fuel consumption. The result was a disaster of monumental proportions as most German heavy divisions promptly ran out of gas and lost, according to various estimates, between 1,200 and 1,500 tanks. See Chapter 11 for additional details.

²² Mierzejewski, *Collapse of the German War Economy*, 167-168. Mierzejewski points out that the Allies didn't recognize what a lucrative target the German railroad network was until January 1945, when Ultra intercepts made clear the chaotic state of the Reichsbahn by this point. He ascribes this to the failure of

Finally, the decisive role of the CBO in breaking the back of the Luftwaffe—by killing its best pilots, starving it for fuel, and forcing it to withdraw the vast majority of its fighters from the fighting fronts—also paid large dividends by reducing casualties among both air and ground forces and shortening the war.²³ Behind these successes stood air intelligence officers gauging, for the most part correctly, the effects and effectiveness of bombing.

1.6 The Unique Difficulties of Air Intelligence and BDA

The Allied air intelligence effort played a crucial role in the success of the major bombing campaigns of 1944-45, but it did so under conditions uniquely difficult among the wartime intelligence services. As John Guilmartin has noted, air intelligence is the most elusive and uncertain of the intelligence disciplines precisely because measuring the effects and effectiveness of air operations is so problematic. “A key problem,” he stated, “is that we approach strategic bombing with the implicit assumption that air campaigns and battles can be judged using the vocabulary, criteria for success or failure, and analytical framework used to evaluate warfare on land and at sea. I contend that the appropriate criteria for judging strategic air campaigns, at least, are quite different and that in consequence the results of the debate [over the value of strategic bombardment in World War II] so far are of dubious validity. As evidence of our incomplete understanding of the nature of aerial warfare, consider the general lack of consensus—or even awareness—of what constitutes an air campaign.”²⁴ Guilmartin’s insights

Allied air intelligence organizations to recognize earlier what was happening, an issue that will receive further attention in Chapter 11.

²³ The best single volume work on the huge air battle of attrition that resulted first in Allied air superiority, and later air supremacy, over the Reich, is Stephen L. McFarland and Wesley Phillips Newton, *To Command the Sky: The Battle for Air Superiority over Germany, 1942-1944* (Washington D.C., Smithsonian Institution Press, 1991).

²⁴ John F. Guilmartin, Jr., unpublished manuscript, “The Aircraft that Decided World War II: Aeronautical Engineering and Grand Strategy, 1933-1945, The American Dimension,” expanded version, USAF Academy 2001, Harmon Memorial Lecture, 2-3.

apply with particular force to the issue of air intelligence in view of its functions as a vehicle for determining enemy vulnerabilities, which during the Second World War revolved around key target sets such as the German aircraft industry, ball-bearings, transportation networks, and oil, and for determining the effects and effectiveness of attacks on those target sets. With these facts in mind, it becomes evident that air intelligence organizations were in the unenviable position of doing the two most difficult things required in air-campaign planning: recommending target sets and, by extension, giving their commanders insights required to develop effective air campaigns.

The trouble with air campaigns, of course, is that their effectiveness tends to be directly proportional to the efficacy of the target-selection process. The selection of specific targets *that can realistically be destroyed and also hold clear promise for helping to achieve a larger military strategy* is vital. In other words, the objective, scope, and duration of air campaigns must be clear, achievable, and bounded by realistic target selection and an intellectually honest conclusion that attacking the selected targets will lead to achievement of the stated objective. This was a serious problem with Air Chief Marshal Arthur Harris's approach to bombing. His objective to destroy Germany's 60 largest cities was daunting in and of itself, but measuring the effectiveness of these attacks was all but impossible because the air intelligence agencies making these assessments had only questionable criteria to employ—the number of destroyed houses and industrial buildings, the number of persons made homeless, and the number killed or wounded—criteria which, ironically, BDA experts assessed with great detail and from which they derived accurate damage estimates. The measurements were precise, but they yielded only uncertainty and growing frustration because this air offensive, which involved several discrete air campaigns

(the Ruhr in 1943-1944 and again in 1944-1945, and the Battle of Berlin, among others), was too unrealistic in its objective, which was to defeat Nazi Germany from the air.²⁵

The consequences of these errors in judgment were injurious both to the proper employment of heavy bombers and the conduct of the air war. The ultimate example of this flawed approach to air campaigning was the Battle of Berlin, a huge, seven-month, night air campaign that was designed to destroy Berlin and knock Germany out of the war. Instead, it nearly destroyed Bomber Command's operational integrity and killed many of its best aircrews. It was, in short, a disastrous defeat for Great Britain, and Germany's last major victory. Much ink has been spilled over Harris and his area city-bombing campaigns, and there is consensus among scholars that his approach to air warfare, and to the air campaigns he directed within the larger context of his offensive against Germany's 60 largest cities, was neither realistic nor achievable. Had Harris listened to the growing chorus of air intelligence officers and senior airmen who assessed his objective (defeat of Nazi Germany from the air) unachievable and his air campaigns of uncertain utility to Allied military strategy, things might have gone very differently with the air war. But he did not listen, and his superiors were unwilling to fire him. Consequently, Bomber Command's failure to knock Germany out of the war stands as testimony that Harris's air campaigns were much less effective than they could have been had he allowed his intelligence staff to choose different targets that were more realistic and in line with the predominant view among Allied military leaders that air power could not defeat Germany on its own.

Portal did eventually lose patience with Harris and demanded that he send Bomber Command's aircraft against oil targets in late 1944 and early 1945. Ironically, these night

²⁵ Harris alluded to a 60-city target list in a memo to Portal, in which he noted that, "In the past 18 months Bomber Command has virtually destroyed 45 out of the leading 60 German cities..." See AIR 8/1745, Memo, Harris to Portal, 1 November 1944.

precision attacks were exceptionally effective and knocked out four of Germany's largest synthetic oil plants for the duration of the war. Harris's bomber crews contributed significantly to the oil offensive by striking the synthetic oil plants, crude oil refineries, and benzol plants in the Ruhr and other areas of western Germany, but they did so in part during the course of area attacks on the cities in which those installations were located, and not by design. In the relatively few instances where Bomber Command aircraft carried out precision raids on oil plants and refineries, Portal had to apply pressure on Harris almost unceasingly to get him to order these attacks. Given Harris's consistent reluctance to attack "panacea targets," including oil plants and refineries, we can only wonder how much more Bomber Command's aircrews might have achieved had they been loosed upon German oil plants and refineries several months earlier and in a concerted fashion as an integrated part of the oil offensive.²⁶

To this most glaring problem with air intelligence, namely, that some commanders—Harris foremost among them—simply would not listen to their intelligence staffs in matters of air-campaign planning, target selection, and BDA, we must add another: the inherent difficulty of gauging the effects and effectiveness of air operations. Unlike ground and naval campaigns, where the parties involved generally know whether the battle was a victory, a draw, or a defeat, air campaigns are prone to uncertainty, and victory or defeat may become evident only gradually, as occurred in the Battle of Berlin. This is due in part to the fact that aircraft must return to base after their missions, leaving the areas attacked in control of the enemy. Consequently, there is only one way to determine whether anything approaching "victory" has been achieved: by

²⁶ The attacks were against Leuna (6-7 December 1944 and 14-15 January 1945), Pölitz (13-14 January 1945 and 8-9 Feb 1945), Brück (16-17 January 1945), and Zeitz (16-17 January 1945). See Martin Middlebrook and Chris Everitt, *The Bomber Command War Diaries: An Operational Reference Book 1939-1945* (Leicester, UK: Midland Publishing, 1996), pp. 628, 652-653, 661, for details. These raids receive further attention in Chapter 11.

deploying air intelligence assets to collect BDA data. During the bombing campaigns against Germany, most of these assets were reconnaissance aircraft, although ULTRA, lower-grade cipher intercepts, and ground sources were also useful, particularly when used to corroborate photointelligence. The problem, of course, was that the photographs, signals intercepts, and ground sources never told the full story but only parts of it, and it was up to air intelligence personnel to construct the rest of the story based on their expertise, experience, and intuition.

Once again, Clausewitz proved uncannily ahead of his time when he referred to intelligence as an occupation particularly prone to uncertainty and inaccuracy. As he noted, "Many intelligence reports in war are contradictory; even more are false, and most are uncertain... This difficulty of *accurate recognition* constitutes one of the most serious sources of friction in war, by making things appear entirely different than what one had expected."²⁷ When viewed in this light, air intelligence and BDA specialists labored under a double burden. First, they sought to make the best use of available intelligence to maximize the friction inflicted on the German war effort. They did so by giving commanders the insights necessary to send bombers after the most lucrative targets. Second, they sought to minimize the many uncertainties surrounding the efficacy of bombing and hence the friction inherent on the *Allied* side of such an effort. They succeeded remarkably well in both cases.

1.7 Allied BDA: Strategy, Synergy, and Serendipity

It was here, in the effort to increase friction throughout the enemy's war effort while reducing it for their own, that the large air intelligence organizations built first by the British and later, with much British assistance, by the Americans, paid their greatest

²⁷ Clausewitz, *On War*, 117.

dividends. To a degree unimaginable even a year or two before the start of the Second World War, British and American air intelligence specialists were able to build a capability that, while far from omniscient, was quite capable of determining the accuracy, effects, and effectiveness of Allied bombing. This was a skill that increased rapidly and steadily as a result of the growing ranks of experienced and skilled air intelligence personnel, the improved analytical and cognitive tools they brought to bear in judging the efficacy of bomber operations, and the rapid growth in the number of reconnaissance aircraft available to the Allies. By the spring of 1944, these improvements resulted in an ability to determine with surprising accuracy and consistency what Allied bombing was doing to the German war effort, and how the Allies could in turn obtain maximum leverage from those effects. The effort was not perfect by any means, but very few things in war, the most unpredictable of human activities, ever come close to achieving perfection. To say that the Allied BDA effort approached perfection more closely than many other aspects of the Allied war effort is an assertion that may invite rejoinders, but one that will nonetheless become increasingly clear in the following chapters.

One of the most striking things about the development of British air intelligence capabilities in particular, and to a lesser degree those of the Americans, is that they were essentially mature and highly capable over two years before the Allies had enough heavy bombers to engage in a major air offensive that could take full advantage of those new capabilities. The reasons for this are complex and will become clear during the course of this work, but for now it is important only to note that both British and American political and military leaders took as an article of faith that they would eventually have enough bombers to attack the German war effort heavily, systematically, and with great effect.

This, along with an effort in both Great Britain and the United States to develop a daylight precision bombing capability in the decade leading up to World War II, helps to explain the heavy and long-term emphasis the British in particular put on the development of first-rate air intelligence and BDA capabilities. This is somewhat easier to understand when we remember that the British planned to use strategic bombing as an economic weapon which, along with naval blockade, was intended to bring Germany to her knees or at least to the negotiating table. However, the intensive British effort to develop an air intelligence capability indicates that they were thinking beyond the idea of bombers as instruments of economic warfare. In fact, they clearly recognized that the air weapon might also strike a heavy military blow while simultaneously creating profound morale problems among the German people. In any case, the British faith that their air intelligence capability would someday have a matching bomber capability paid off when American bombers began arriving in large numbers in 1943. At one point early in the war, Air Chief Marshal Charles Portal, the British Chief of Air Staff, told Prime Minister Winston Churchill that it would take 4,000 bombers six months to destroy the German war economy and undermine her people's morale. If he erred in believing that a collapse of German morale might end the war, his estimate that 4,000 bombers could do grievous harm to the Third Reich's war effort proved to be almost exactly on the mark.²⁸

Allied bombing did in fact get into high gear once 4,000 operational bombers were on hand in the spring of 1944. The BDA capabilities required to steer this massive aerial armada were also in place by then in the form of several key organizations and hundreds of personnel dedicated to discerning the effects and effectiveness of bombing. They did

²⁸ AIR 8/440, Minute, Portal to Churchill, 25 September 1941.

this by giving commanders the BDA they needed to make proper decisions about where to commit their bombers, and about how best to adjust target priorities during the course each bombing campaign in order to have the maximum effect on the German war effort. Air intelligence and BDA efforts did this by focusing on three major target sets from the late winter and early spring of 1944 to VE Day: the Luftwaffe, oil, and transportation (referred to at the time as communications targets). They added a fourth—armored fighting vehicle (AFV) production—in early 1945. The accuracy and swiftness with which the various committees and organizations involved in these targeting and BDA efforts discerned the effects and effectiveness of bombing were in most cases very good. There were failures, but from spring 1944 to VE Day, the BDA effort was effective.²⁹

This effectiveness revolved around one of the great and little-recognized truths of the air war: the British, who developed an air intelligence structure capable of discerning, targeting, and conducting detailed BDA for specific target sets vital to the German war effort, were in fact ideally structured to provide BDA and other types of air intelligence for the American high-altitude, precision, daylight bombardment effort. They were, of course, also quite capable of assessing the results of Bomber Command's city raids, but

²⁹ The least effective BDA effort was the one for transportation targets in the Reich. As Mierzejewski demonstrates expertly in *The Destruction of the German War Economy*, 165-168, only SHAEF G-2 (Intelligence Directorate) recognized clearly the disastrous effects a heavy bombing of German marshalling yards would have on the movement of coal, the lifeblood of the German economy. The Combined Strategic Targets Committee (CSTC) Working Committee for transportation targets was less sanguine about the possibilities involved, incorrectly as it turned out. However, Mierzejewski does not provide the larger context within which these issues were discussed, namely, that the majority of the CSTC's efforts were focused on the oil offensive, which was already having dramatic effects on German air and ground forces. If the CSTC failed immediately to appreciate the potentially decisive *economic* impacts of attacks on German marshalling yards, they saw with absolute clarity the decisive *military* effects of the oil offensive and the earlier transportation offensive against French and Belgian railroad networks. Equally important is the fact that Group Captain Morley, SHAEF's representative on the CSTC, was in fact just that: a full-time and fully accredited member of the CSTC, and it was due in part to his efforts that the campaign against German marshalling yards became a reality. In other words, the CSTC machinery worked, imperfectly to be sure, but effectively over time. This issue receives a closer look in Chapter 11.

there was a unique fit between what we might call British precision BDA and American precision bombing. As the USAAF air intelligence effort got into high gear, a number of American officers commented on how effectively the British supported American BDA requirements. Indeed, by late 1944 USAAF commanders had grown concerned with what they viewed as excessive American reliance on British air intelligence.³⁰

1.8 Scope of the Study and Varieties of BDA

Although the majority of this work deals with BDA produced to assess the effects and effectiveness of Allied heavy bomber campaigns during the Second World War, it also addresses the beginnings of BDA during the First World War, when a rudimentary but surprisingly large intellectual infrastructure, including aerial reconnaissance capabilities, air intelligence organizations, and formal BDA reports—many of them quite accurate—emerged in both the British and American air arms by early 1918. To provide a sense of continuity and assess the effectiveness of the BDA effort during World War II, it also assesses, in a cursory fashion, BDA developments during the postwar period.

In attempting to gauge the efficacy of BDA efforts in these various armed conflicts, it is important first to recognize that there were in essence three kinds of BDA (and

³⁰ Brigadier General Alfred Maxwell, the American Co-Chairman of the CSTC, expressed these sentiments in a letter to the British CSTC Co-Chairman, Air Commodore Sidney Bufton, when he said, "My organization owes a debt of gratitude to the RAF, which has both housed us and taught us the way toward improved intelligence." See AIR 2/8011, Memo, Maxwell to Bufton, 8 May 1945. As for American concerns about their dependence on British air intelligence, Major General Fred Anderson, USSTAF Deputy Commanding General for Operations, told Brigadier General George C. McDonald, the USSTAF A-2 (Director of Intelligence) that USSTAF was far too dependent upon British intelligence, as had been made clear many times. He noted that "We have built up here the only really competent Intelligence service that exists or has existed in the Air Forces of the United States." Nonetheless, he continued, "If it would become necessary for us to break off from British sources of Intelligence at short notice we would be lost." Anderson noted that it would take a major expansion to collect, analyze, and disseminate intelligence at the same level as did the British—an expansion impossible over the short term given training and manpower limitations. See Spaatz Collection, Box 297, "Conference held in the Office of the Deputy Commander, Operations, USSTAF, 9 October 1944; Subject: The formation of an Intelligence organization to supply overall requirements of Air Forces in this Theater as divorced from British Intelligence sources."

MEA) performed during one or more of them. The first involved making assessments about the accuracy, effects, and effectiveness of airpower during the course of the conflict, and when there was no ground access to targets other than that gained infrequently by agents, whose reports were often inaccurate. In this instance, knowledge was most incomplete and the conclusions drawn about BDA and MEA most subject to error. Even the highly developed Allied photoreconnaissance and photointerpretation capabilities developed by the last two years of World War II provided incomplete knowledge of the effects and effectiveness of bombing raids, as do the excellent but nonetheless exaggerated capabilities provided by satellites and unmanned aerial vehicles (UAVs) today. Put simply, lack of direct ground access to targets has always placed limitations on what BDA experts can piece together from available sources.

The second variety of BDA, which occurred only during the Second World War, was the combination of traditional BDA (in other words, that conducted without the benefit of ground access to the targets being assessed) with a direct knowledge of targets gained *during and after* a successful military campaign or operation in which Allied ground forces overran key bombing targets and BDA ground survey teams gained direct access to them. Every bit as important as direct access to these targets was the ability to interrogate the enemy civilian and military personnel who kept meticulous records of the damage done by each raid, the level of success achieved by repair crews, the effects of the bombing on the functioning of each target, and in certain cases the wider effects on Germany's war effort. This *ex post facto* BDA, conducted continuously throughout the course of the war, began in the North African campaign, continued with the first transportation offensive in Italy and the second transportation offensive in France and the

Low Countries, and culminated with the oil offensive and the third transportation offensive against Germany. Each of these discrete air campaigns provided numerous lessons, which Allied air intelligence personnel applied from one to the next. A similar dynamic has been at work in the U.S. Air Force since 1990, as BDA lessons-learned have been discussed and applied—if only erratically—to the air campaigns of the 1990s and the first decade of the 21st century. However, the learning that has occurred during this later period has been far less systematic and productive than the learning that went on during the successive Allied air campaigns against Nazi Germany.

The crucial benefit derived from this ongoing BDA effort during the Second World War was an iterative learning process in which Allied BDA and MEA experts were able to draw important lessons from the bombing effort, many of them gleaned from their direct access to the targets, enemy personnel associated with those targets, and the records they kept, *as it was in progress* and then apply them to subsequent bombing campaigns and raids. Consequently, the effects and effectiveness of Allied bombing increased during each of these heavy-bomber campaigns as air intelligence personnel brought new tools and insights to bear.

The third kind of BDA was that conducted after the end of hostilities, when Allied troops occupied western Germany, giving ground survey teams direct access to all targets of interest as well as the ability to interview civilian and military officials affiliated with the operation and repair of facilities bombed by the Allies. In both 1918-19 and 1945-46, British and American ground survey teams collected an incredible quantity of data, particularly in the case of the United States Strategic Bombing Survey (USSBS), which totaled over 200 bound volumes, describing the effects and effectiveness of the bombing

of virtually every kind of industrial and military target set attacked by Allied bombers during the Second World War. A similar process occurred after the first Gulf War, resulting in the publication of the Gulf War Air Power Survey (GWAPS), but there has been no such systematic effort in the air campaigns of the past decade.

Because Allied air intelligence personnel during the First World War had access only to the first and third of these types of BDA and MEA, lacked anything like the photoreconnaissance and photointelligence capabilities available to their successors in World War II, and had to grapple with what was then a brand-new kind of warfare, their assessments tended to be shallow and often incorrect. Yet at times they were also sophisticated and more accurate than one might have thought possible given the embryonic and uncertain nature of BDA and MEA at that time.

During the Second World War, the *intellectual infrastructure* required to perform BDA, which had as its predecessor a rudimentary version in World War I, came of age. It included a closely interwoven collection of air intelligence agencies and organizations, and photoreconnaissance units, which, collectively, gave Allied political leaders and military commanders a very good understanding of the German war effort and the ways in which bombing could degrade it; the world's best photoreconnaissance aircraft as well as the cameras and advanced films and techniques required to provide high-resolution and very high-quality prints of virtually every German structure and activity of note; signals intelligence capabilities; and above all the highly skilled and experienced photointerpreters and other air intelligence personnel required to make sense of the data collected. The vast differences in BDA expertise between the two wars began to become clear, in the case of the British, during the last years of the interwar period. By 1943

there was no mistaking the huge advances in this arena. Of paramount importance in the success of BDA and MEA efforts in the 1939-45 conflict was the fact that air intelligence personnel had direct access to targets that had been attacked, and the enemy officials associated with them, once they were captured by Allied armies. As noted earlier, this ability to implement an iterative learning process—which the British and Americans did exceptionally well—proved pivotal in the rapid development of BDA capabilities and their employment in support of the CBO and the larger Allied war effort. It was precisely the length, breadth, and fluidity of the Second World War, particularly once the tide had turned and the Allies were advancing on all fronts, that allowed for this iterative process, which was notably absent in the First World War and could not in any case have been turned to anything approaching the advantage to which it was turned in World War II.

1.9 Organization of This Work

This introductory chapter has set forth the basic arguments and terms of reference relating to the practice of BDA. Chapter 2 addresses early BDA developments during the First World War, including the emergence of a rudimentary but recognizable intellectual infrastructure that included new organizations, air intelligence specialists, and advanced technologies that came together for the first time to allow British and American senior airmen to gauge the effects and effectiveness of their bombing operations. Chapter 3 focuses specifically on the British and American bombing surveys completed in the months following the end of hostilities in November 1918. Chapter 4 looks at BDA-related retrenchment in the early interwar period (1919-1932), during which the intellectual infrastructure that emerged in World War I largely vanished, and also at the surprising degree of continuity and advance of certain facets of the old intellectual

infrastructure, most notably developments in aerial photography. Chapter 5 addresses BDA developments during the late interwar period (1933-1939 for the British; 1933-1941 for the Americans), when the threat posed by Nazi Germany became significant.

From there, Chapter 6 addresses the reemergence of an intellectual infrastructure in the first two years of World War II, during which three new British BDA-producing organizations—the Ministry of Economic Warfare (MEW), Research and Experiments Department 8 (RE8), and the Central Interpretation Unit—emerged and began a rapid development process that included increasingly close ties between these three key organizations and the Air Ministry Intelligence Section. At the same time, a revolutionary new photoreconnaissance aircraft, the Spitfire PR1, made possible the rapid collection of photographic cover for every major German city, industrial concern, and military installation. The chapter also traces how the misfortunes of Bomber Command in the war's first two years interacted with the development of British BDA capabilities.

Chapter 7 assesses the increasingly rapid BDA-related developments of 1941 and 1942, a crucial period during which the British intellectual infrastructure reached maturity and was tested by two major developments: the start of RAF Bomber Command's major night area bombing campaigns against German cities, and the arrival of the first American air intelligence officers in the European Theater of Operations (ETO). These Americans went to work alongside their British counterparts at the Air Ministry, RE8, and the CIU, learning from them and in the process providing a nucleus of trained officers to serve on American headquarters staffs, including Eighth Air Force, and with the first American photoreconnaissance squadrons to arrive in the ETO. This chapter will also address how the development of BDA capabilities in the Sicilian and

Italian campaigns (where the first of three transportation offensives began in the summer of 1943) influenced, and was in turn influenced by, BDA developments in the UK, particularly at the DIU, RAF Bomber Command, and Eighth Air Force. Finally, the chapter will look in some detail at the serendipitous relationship that developed between British “precision” BDA and American “precision” bombing, a relationship that flourished beginning in summer 1942 and continuing until the end of the war.

Chapter 8 addresses the emergence of a mature BDA intellectual infrastructure in 1943 and early 1944, which allowed the Allies to make accurate judgments about the effects and effectiveness of bomber operations against transportation, oil, and other target sets. The ACIU and the Joint Photographic Reconnaissance Committee (JPRC) take center stage here, as the former became a combined Anglo-American photointerpretation capability and the latter provided a highly effective requirements-management function facilitating the rapid and effective collection, processing, and dissemination of BDA reports and photographs. Also central to this maturation process was the development of close ties and clearly-defined working relationships between the ACIU, MEW, RE8, the Railway Research Service, and several other key air and economic intelligence agencies.

Chapter 9 focuses on the first major transportation campaign in northwestern Europe: the pre-invasion attack on railroads and canals in France and Belgium. This was the first campaign in which the iterative learning process discussed earlier had an opportunity to take full effect. Despite disagreements between British and American air intelligence personnel and operational commanders about the proper targets for this air offensive (the British pushed for concerted attacks on major marshalling yards; the Americans for attacks on bridges and oil targets), an abundance of heavy and medium bombers allowed

the Allies to go after all three, another serendipitous development in which the synergistic effects produced by simultaneous attacks on all three target sets resulted in a dramatically effective Allied air effort and a series of unmitigated military disasters for the Germans.

The focus in Chapter 10 shifts to the oil offensive, which had its genesis in General Spaatz's recommendation that oil, and not transportation, be the focus of pre-invasion heavy bomber attacks. General Eisenhower opted instead for the transportation plan put forth by Air Chief Marshal Tedder (Eisenhower's Deputy Supreme Allied Commander) and his chief scientific advisor, Solly Zuckerman, but he nonetheless quietly gave Spaatz the authority to launch a major series of raids on German synthetic oil plants on 12 May 1944. The BDA reports for these first raids, comprised of photoreconnaissance cover corroborated by Ultra intercepts (referred to from this point forward as PR cover), made it abundantly clear that the Allies had found a—perhaps *the*—key German vulnerability. From this point forward, oil became the number one target set, with the transportation campaign in France and the Low Countries, followed by the third and last major transportation campaign, this one against the Reich itself, assuming second priority on the recommendation of nearly all the major air intelligence agencies and officers in the ETO.

As Allied BDA reports demonstrated from the outset, the oil offensive had an increasingly disastrous effect on German military operations, beginning almost immediately with a severe aviation fuel shortage that kept the majority of the Luftwaffe grounded for the rest of the war, and continuing with a severe gasoline shortage among German units on the Western Front, which was the result of synergy between the transportation and oil offensives. This gasoline shortage ultimately undermined the Ardennes offensive and, after that, resulted in a cataclysm on Eastern Front in January

and February 1945, during which the Germans lost thousands of tanks, halftracks, trucks, and artillery pieces as a result of catastrophic gasoline shortages brought on by Allied bombing and by Hitler's gamble in the Ardennes, which consumed *half* of the remaining fuel production for the months of November and December 1944, which left far too little fuel to replenish fuel stocks on the Eastern Front. The cataclysm occurred when an unexpected Red Army winter offensive caught the Germans without adequate fuel to conduct a battle of maneuver. A crucial aspect of these developments was the fact that Allied BDA experts and commanders anticipated them and recommended a continued all-out effort against oil targets with the explicit purpose of creating the conditions for the disaster that overtook German armies between December 1944 and February 1945.

In Chapter 11, the focus on oil continues, but in conjunction with the transportation offensive against the Third Reich itself and the synergy between these two efforts. Aside from causing the collapse of the German war economy, attacks on German railroads and canals interacted with the continuing oil offensive to create a situation in which the German army's last stand on the borders of the Reich, which might have lasted far longer than it did and exacted a much higher toll from Allied armies in the absence of the oil and transportation offensives, instead collapsed within a matter of weeks in the late winter and spring of 1945. The transportation offensive against Germany was the most contentious air campaign from a BDA perspective because the CSTC's Transportation Working Committee had internal disagreements about how best to proceed. In fact, it took a good bit of pressure from SHAEF G-2, which recognized that concerted attacks on German marshalling yards and inland waterways might precipitate a major economic and military crisis in the Reich, to get the CSTC and other targeting and BDA organizations

to march in step. Once they did, however, the results were immediate and profoundly negative for the Germans, whose railroad network and inland waterways were rendered almost entirely inoperative, stopping coal deliveries to German war industries, which in turn brought war production, if not entirely to a halt, then nearly so. This third and largest of the transportation offensives also resulted in a distribution crisis of epic proportions. German industry, which had dispersed in response to increasingly heavy Bomber Command and USAAF raids, relied on the Reichsbahn for the movement of components for various weapon systems to the locations at which final assembly took place. The Allied air attacks undermined this process and also played havoc with the movement of finished weapons, ammunition, and fuel to the fighting fronts. Once the German railways collapsed, Germany's final defeat was not far behind.

Chapter 12 provides a retrospective on the role of air intelligence, and in particular BDA, in the Allied victory. Employing both wartime BDA and the *ex post facto* BDA collected by the United States Strategic Bombing Survey and the British Bombing Survey Unit in the months after VE Day, this chapter examines the ways in which BDA helped Allied operational commanders to steer their heavy bombers to the most lucrative target sets. It also discusses some of the missed opportunities, from a targeting and BDA standpoint, including the failure to attack power plants and tetraethyl lead production facilities, the first of which could have paralyzed German industry, and the second of which would have made it impossible for the Germans to produce the additives required for the manufacture of high-octane aviation fuel.

In Chapter 13, the focus shifts to American BDA in the postwar period, beginning with the Korean War and culminating with a discussion of BDA in the second Gulf War.

The emphasis here will be on assessing the degree to which the BDA process in World War II has been applicable to these more recent armed conflicts, and, if applicable, the degree to which American air intelligence officers and operational commanders have learned from the BDA experiences of 1941-45. Although, as Michael Howard has noted, trying to draw lessons from history is a perilous business, there are clearly a number of “approximate precedents,” as Andrew Gordon called them, to which the current generation of officers can refer in planning air campaigns and providing effective BDA capabilities to determine their effectiveness.³¹ It is in this intersection of past, present, and future, that the “approximate precedents” to be drawn from Allied BDA efforts in World War II will be of the greatest use to today’s and tomorrow’s military officers.

³¹ Andrew Gordon, *The Rules of the Game: Jutland and British Naval Command* (Annapolis, MD: Naval Institute Press, 1996), 578-601. Gordon’s “approximate precedents” (which he derived from what he referred to as “syndromes” in British naval command culture before and during World War I) represent one of the very few efforts on the part of a historian to discuss how the present generation of officers might learn from the mistakes—and the successes—of past military campaigns and command cultures. In this sense, Gordon’s effort acts as a model for this work’s final chapter.

CHAPTER 2

THE GREAT WAR AND THE BEGINNINGS OF BDA

2.1 Bombing and BDA: Rudimentary but Evolving Capabilities

The air weapon evolved quickly during the First World War. From its humble beginnings as a reconnaissance and observation platform, the airplane soon demonstrated its value as a means of conducting reconnaissance, spotting and correcting fire for artillery, gaining and maintaining air superiority over specific areas, and bombing. In the latter role, aircraft served both tactical and strategic purposes. The belligerents on the Western Front viewed bombers as flying artillery platforms with greater range and mobility than conventional artillery and, later, as independent bombing machines capable of influencing the enemy's will and ability to continue the war by attacking his war industry, his morale, or both. However, with a few notable exceptions, there was relatively little effort during World War I to employ the bomber as a weapon to be used independently of ground forces for strategic purposes such as destroying enemy war industry or undermining a civilian population's morale.¹ In fact, bombers were for the most part viewed as flying artillery to be used within or outside the range of conventional artillery, but as artillery nonetheless. Even the employment of Allied bombers in large

¹ These exceptions include the German Naval Air Service Zeppelin campaign 1915-18, a minor French effort against industrial targets in Alsace-Lorraine in 1915, German Gotha and Giant heavy bomber raids on London in the summer and fall of 1917, and the Italian bombing campaign against Vienna. The RAF Independent Force (IF) operations in 1918 were also, in theory, designed to achieve strategic effects by attacking German nitrogen-fixation plants to undermine the production of explosives and ammunition, an effort that never occurred because the bombers were diverted to other uses. Details follow in this chapter.

formations during the St. Mihiel and Meuse-Argonne offensives, as important as it was for the development of bomb damage assessment (BDA) techniques, represented a tactical and operational employment of bombers in direct support of ground forces, rather than for separate strategic purposes.

Consequently, efforts to develop BDA capabilities during the war relied heavily on tools and techniques already in use to determine the effects and effectiveness of artillery barrages. Only late in the war, as more capable bombers with larger bombs and longer ranges emerged, did BDA become a distinct field of air intelligence expertise focused specifically on the results of aerial bombardment, with the intellectual, organizational, technological, and training innovations this involved.² By extension, efforts to conduct BDA involved an evolutionary process that had its roots in artillery employment as well as nascent air doctrine. The essence of BDA came to involve understanding the *effects* of an attack as well as its *effectiveness*. The former involved determining physical and morale effects, while the latter sought to understand how a particular bombing raid contributed to achieving military and policy objectives at the tactical, operational, and strategic levels. To determine effects and effectiveness, intelligence officers had to learn specific skills that comprised the two halves of what came to be known during World War II as BDA: *bomb damage assessment* (BDA) and *munitions effectiveness assessment* (MEA). The first involved determining the damage bombs had done to a target, while the

² It is worth noting that bombers, which did not even exist as a distinct class of aircraft in 1914, were becoming quite capable by the end of the war. The Handley Page V/1500, of which three were in service when the Armistice was signed, had a range of 1,300 miles and a maximum bomb load of 7,500 pounds. A bomber with these capabilities was clearly capable of conducting strategic bombardment campaigns, which had obvious implications for associated BDA capabilities, including intelligence and aerial reconnaissance. See C. H. Barnes, *Handley Page Aircraft since 1907* (London: Putnam, 1976), 47.

second looked at how well specific munitions worked against that target. Both skills were evolving rapidly by the end of World War I, but neither was close to maturity.

However, to say that BDA was not a mature process by the end of World War I is not to say it received no attention at all. In fact, airmen—flyers and intelligence officers—were heavily involved in developing the technologies, training, organizations, and the *intellectual infrastructure*, or overall framework, that came to characterize the mature BDA process during World War II. British and American airmen who planned and executed bombing missions and conducted post-strike assessments came to understand that both halves of the equation—BDA and MEA—were central to the question of bombing effects and effectiveness. Although both activities evolved rapidly during the last year of the war, they fell into obscurity again during the interwar period, only to reemerge with astonishing speed and vigor during World War II.³

Of the crucial elements comprising a mature BDA capability—technology, technicians, training, organization, and intellectual infrastructure—the latter is the most difficult to develop and keep in place over the long term because it involves the integration, synchronization, and direction of the other four elements. The first of these, technology, included reconnaissance and bombing aircraft large enough to carry cameras; cameras, plates, and film; stereoscopic viewing devices; and photographic development equipment that allowed for rapid exposure of prints. All became better as the war continued and were adequate for gathering the photographs required for BDA. These

³ The United States Air Force currently uses the term “combat assessment” to encompass both bomb damage assessment and munitions effectiveness assessment. However, during World War II, the term “bomb damage assessment” (or “BDA” for short) actually encompassed both. There was no clear or consistent terminology in use during the First World War, so the terms “bomb damage assessment” and “BDA” are used here both as a matter of simplicity and to provide consistency in the narrative.

technologies evolved further during the interwar years, as private industries worked with air officers in Britain and the United States to give them a crucial boost towards maturity.

The emergence of technicians, including photographic and intelligence officers, and training programs for them, also accelerated as the war continued. Improvements here were twofold. First, photographic personnel learned to mount cameras on aircraft, maintaining them between missions, removing the plates or film without causing damage, and developing photographs in the darkroom. Second, and crucial for the purpose of conducting BDA, was the emergence of a new kind of specialist: the branch intelligence officer. These officers, who emerged in British and American air units in late 1917, were generalists trained to understand and employ all available intelligence sources. They were not trained specifically as photointerpreters but did have a basic understanding of photointelligence and its value to the BDA process. Branch intelligence officers developed a symbiotic relationship with photographic officers, but there was friction between them, including an unclear division of labor and, consequently, duplication of effort. These problems were not solved until the early years of World War II.

This friction between intelligence and photographic officers was one aspect of the organizational challenges brought on by the emerging requirement for BDA. In the case of the RAF's newly-created Air Ministry, these included convoluted reporting chains, competition between various offices in the ministry, and other problems that impeded the evolution and the effectiveness of BDA-related organizations at all echelons. On the American side, flaws in the tasking process for reconnaissance aircraft as well as unclear lines of authority between intelligence and operations hampered BDA development.

The key factor in the development of BDA procedures, however, was the emergence of an intellectual infrastructure. This involved not only the sum total of the technology, technicians, training, and organization, but two other crucial elements: *experience* and *guidance*. With one exception—British Royal Naval Air Service (RNAS) bomber raids against German U-boat bases along the Belgian coast and Zeppelin factories in western Germany—little experience existed until 1917-18. Bombers and bombing were too new, the technologies involved too rudimentary, and nobody had ever before practiced BDA as a distinct analytical skill. Artillery damage assessments provided a start, but BDA, as it was practiced by 1918, and as it reached maturity in World War II, was a distinct skill requiring unique tools and insights. Clear guidance was also absent until late 1917. Airmen recognized that BDA was something new, but they did not fully understand until World War II which functions BDA and MEA should perform in a bombing campaign, and how best to structure and task the units and agencies engaged in the BDA process.

Despite rapid development during the First World War, aircraft were still fragile, dangerous, and ineffective bombing platforms until the closing months of the conflict. This impeded the development of bombing and BDA even as it spurred debate among military officers about the uses of bombing and the tools required to measure its effects and effectiveness. Although these tools remained rudimentary during the war, they demonstrate that British and American officers thought seriously about how best to employ bombing to maximize damage and how to structure the damage assessment process. This link between targeting, bombing operations, and BDA is crucial. As one scholar has emphasized, “in essence, air power is targeting, targeting is intelligence, and

intelligence is analyzing the effects of air operations.”⁴ In this sense, BDA had its origins in the development of strategic bombing theory and practice during the Great War.⁵

The Great Powers were all thinking about the employment of bombers for strategic purposes in the years leading up to the war. H. G. Wells’ *War in the Air* posited a long and indecisive “universal guerrilla war” in the air featuring long-range bombers, the destruction of cities, famine, and mass death, firing popular imagination and fears.⁶ The emergence of the Zeppelin fleet in Germany seemed to confirm that the bomber, at least a lighter-than-air version, would soon be able to inflict the horrors envisioned by Wells.⁷ At the same time, the French, British, and Germans began testing aircraft, bombs, and bombsights to determine the bomber’s potential utility. Although these first steps yielded few results, they marked the start of a huge research, development, testing, and evaluation (RDTE) process for bombing that matured during World War II.⁸

2.2 Bombing as Artillery: The Effects on BDA Development

During the first year of World War I, bombing operations consisted largely of haphazard, uncoordinated, and opportunistic attacks by aircrews flying reconnaissance missions in support of ground forces. These sporadic and uncoordinated attacks

⁴ Meilinger, *10 Propositions Regarding Air Power*, 20.

⁵ The theoretical and practical differences between “strategic” bombing on the one hand, and “tactical” bombing on the other, are worth defining. Strategic bombing, as it was practiced in embryonic form in World War I and then more fully in World War II, sought to weaken or undermine the enemy’s war effort by degrading his war industry, undermining his morale, or both. “Tactical” bombing included attacks on targets both in and beyond the range of friendly artillery fire. The former is now known as close air support (air attacks in direct support of friendly ground forces), while the latter is now referred to as battle area interdiction, which includes attacks on enemy lines of communication, marshalling yards, supply depots, and even industrial targets, but in support of friendly ground forces during a specific military campaign or engagement, rather than for independent strategic aims. American and Allied bombing during the St. Mihiel and Meuse-Argonne offensives fit in the “tactical” category.

⁶ H. G. Wells, *The War in the Air* (London: Grosset and Dunlap, 1907), 253, 352.

⁷ Lee Kennett, *A History of Strategic Bombing* (New York: Free Press, 1982), 17.

⁸ *Ibid.*, 45. The best account of the development of bombsights is Stephen L. McFarland, *America’s Pursuit of Precision Bombing, 1910-1945* (Washington D.C.: Smithsonian Institution Press, 1995). A monograph on the development of aerial munitions has yet to be written.

consisted of lobbing a grenade or a slightly modified artillery projectile over the side of the aircraft in the hope that it might hit something and cause damage. By November, reconnaissance aircraft carried one or more small bombs to take advantage of targets of opportunity.⁹ At year's end, however, the target-rich environment was replaced by one in which trenches and dugouts yielded very few opportunities for these amateur "bomber crews" to practice their new additional duty.

The absence of purpose-built bombers, aircrew navigational skills, effective bombsights, and reliable munitions, and the lack of an intellectual infrastructure upon which to base bombing operations, meant that bombing evolved initially through a series of *ad hoc* expedients, without any BDA capability beyond what the pilot or observer managed to see over his shoulder. Only in November 1917 did British bomb squadrons begin receiving cameras for recording bomb damage, photographic sections for developing imagery, and intelligence sections to interpret strike photographs as they sought to assess the effects and effectiveness of bombing raids.¹⁰ Even the German Zeppelin raids on Great Britain and RNAS retaliatory strikes against airship pens, factories, and repair facilities were carried out with rudimentary tools and an almost complete lack of any damage-assessment process beyond what the airship and aircraft crews could actually see while the raids were in progress.¹¹ In fact, Peter Strasser, commander of the German Naval Airship Division, recognized the futility of doing serious material damage, betting instead on causing panic among British civilians, who,

⁹ Lee Kennett, *The First Air War, 1914-1918* (New York: Free Press, 1991), 47.

¹⁰ George K. Williams, *Biplanes and Bombsights: British Bombing in World War I* (Maxwell AFB, AL: Air University Press, 1999), 81-82.

¹¹ See AFHRA 512.041-26, Air Ministry, Air Historical Branch 1, *The RAF in the Bombing Offensive against Germany, Vol. 1, Prewar Evolution of Bomber Command, 1917-1939*, 1945, 5-8, for a succinct look at the lack of formal BDA during the first three years of the war.

he believed, would demand that their government capitulate. This fixation on morale bombing, which emerged later in Britain, had serious implications for the development of BDA, including the notion that rigorous damage assessments were unnecessary because bombs would have serious morale effects wherever they fell and could, on this basis alone, be expected to compel an enemy to capitulate.¹²

However, to say that no true intellectual infrastructure for BDA existed before 1917 is not to say that nothing happened prior to that. The first serious effort to produce damage assessments occurred in the RNAS during the last three months of 1914. Raids on the Zeppelin Factory at Friedrichshafen, on Zeppelin sheds at Düsseldorf and Cologne, and against German naval bases in Belgium made clear the necessity for developing some means for assessing the effects of these early raids. The RNAS attempted to address this requirement with the development of a small intelligence section responsible for producing BDA reports on individual raids and cumulative results for periods ranging from one to eight months. These assessments relied almost entirely on aircrew reports, agent reports, and German as well as neutral country newspaper articles. There were no cameras aboard the aircraft at this stage, nor were their dedicated reconnaissance sorties for these raids, so neither strike photographs nor reconnaissance cover existed. For the most part, available sources were sketchy and inaccurate, but there were notable exceptions, such as the destruction of a Zeppelin and its shed at Düsseldorf on 8 October 1914, after which the pilot's report that flames 300 feet high shot up the

¹² D. H. Robinson, *The Zeppelin in Combat: A History of the German Naval Airship Division* (Sun Valley, CA: John W. Caler Publications, 1971), 17, 50. See also AIR 2/123, the report produced as a result of the interrogation of the crew of Zeppelin L.33. Lt. Ernst W. Schirlitz, second in command of the airship, admitted that he dropped bombs without consulting a map and without any clear idea about where he was when he dropped them.

entire length of the shed was corroborated by reliable agent reports. In another case, Allied agents intercepted a letter sent from Belgium to Amsterdam in which an individual with firsthand knowledge of damage to Zeppelin sheds in Belgium described the effects of RNAS bombing. Nonetheless, dramatic and obvious cases of success, as in the raid on Düsseldorf, and reliable letters such as the one just described, were exceptions to the rule during the period prior to 1917. For the most part, the sources RNAS officers relied upon for BDA inputs were either unreliable or provided limited insights. Truly effective BDA reports would await the arrival of bombers equipped with cameras for strike photography, and reconnaissance aircraft to ascertain the results of raids after the fact.¹³

RNAS raids continued unabated in 1915, with attacks on the German naval base at Zeebrugge taking precedence. One of the most striking things about these raids was the small size of bombs employed, most of which were 20-lb. HE and fragmentation bombs. The fragile bombing platforms available at the time were incapable of carrying more than three 100-lb. bombs, which were in any case still uncommon at this point, and in general carried only three or four 20-lb. bombs. For the 35 sorties against German naval targets at Zeebrugge and other bases on 11 and 12 February 1915, RNAS airmen dropped only 3,100 lbs. of bombs—just over a ton and a half—comprised of thirteen 100-lb. weapons

¹³ See, for instance, AIR 1/2099/207/20/1, Royal Naval Air Service, "Reports on the Air Attacks on Düsseldorf and Cologne," 1st September to 31st October, 1914," 6 November 1914, 15, 31-32. These reports, which comprised the first formal BDA effort in the history of air warfare, relied entirely on aircrew and agent reports along with newspaper clippings from German and neutral newspapers. It is also worth a brief reminder about the fragility of aircraft involved in these early bomber raids. Both of the RNAS aircraft sent out on the 8 October 1914 mission crashed, but their pilots were uninjured and made it back to base on foot and by car. The text of the intercepted letter is in AIR 1/2099/207/20/1, Royal Naval Air Service, "Report of Damage Done to the Enemy during Operations of the Royal Naval Air Service, October 1914 to June 1915," July 1915, 16. It read in part that "...the first bombs dropped on the Evere [Zeppelin] shed [in Belgium], where two new Zeppelins were destroyed..." A source in Belgium corroborated this letter in part, claiming that only one Zeppelin L.38 was destroyed, 10 men killed, 15 wounded, and 17 small bombs set on fire. The sources estimated total damage at 5 million Marks.

and 107 of the 20-lb. variety. This presented a double problem for RNAS intelligence officers trying to gauge the effects of these attacks. They had to obtain reliable information, which was scarce, and then try to determine weapons effects. Nonetheless, RNAS intelligence officers gradually came to realize that 20-lb. bombs did no damage worthy of the name, while the 100-lb. variety, though much more destructive, had clear limitations when dropped on hardened targets such as U-boat anchorages.¹⁴

As the RNAS bombing offensive developed in 1915, the French air service and the British Army's Royal Flying Corps (RFC, which did not become the independent RAF until 1 April 1918) developed formal bombing directives. These, however, were short on details about navigating to the target, weapons delivery, or damage assessment. The British directive, for instance, simply recommended that aircrews release their bombs at 500 feet or less of altitude, which would help them place their bombs within 50 yards of the target. The French version emphasized practice with dummy bombs and promised an effective bombsight would soon be available. Both documents recommended several targets suitable for aerial bombardment, most of which were beyond the range of friendly artillery. The most prominent included artillery batteries, airfields, road and rail lines of communication, trains, barracks, supply depots, and, later in the war, enemy industry.¹⁵

The Battle of Loos in September 1915 marked the first point at which purpose-built British bombers with specially-designed bombsights and munitions, under centralized

¹⁴ For details on the raids of 11-12 February 1915, see AIR 1/2099/207/20/1, Royal Naval Air Service, "Reports of Air Attacks on Zeebrugge-Ostend District, 11th, 12th, and 16th February, 1915," May 1915, 3-5.

¹⁵ *Instruction sur l'organisation et l'emploi des groupes des bombardement*, Feb. 1, 1915, referenced in Kennett, *The First Air War*, 48; "Bomb Dropping Attacks," Feb. 1915, referenced in Richard J. Overy, "Strategic Bombardment before 1939: Doctrine, Planning, and Operations," in R. Cargill Hall, ed., *Case Studies in Strategic Bombardment* (Washington D.C.: Air Force History and Museums Programs, 1998), 14.

control, attacked German targets beyond the range of artillery. However, the first formal RFC BDA report on record, comprised entirely of pilots' reports, recorded the results of seven sorties flown in May 1915—four months earlier. Despite the poor bombing results recorded in this report, the RFC was now in the BDA business and developed increasingly sophisticated damage assessments between 1915 and 1917.¹⁶ However, bombers continued to receive lower priority than fighters until the end of the war. In November 1918, of the 1,659 British aircraft on the Western Front, only 401, or 24 percent, were bombers. Of these, 371 were single-engine models with limited range and small bomb loads, making them inadequate for long-range bombing.¹⁷ Bomb tonnage dropped by British bombers reflected this minor effort, with 5.5 tons dropped during the Battle of Loos, compared to 420 tons in March 1918, and 948 tons in August 1918.¹⁸

The fact that targets listed in British (and later American) directives were mostly beyond the range of artillery but directly related to the ground war provides a crucial reminder that senior officers viewed bombers as extensions of artillery. This would have major ramifications for bombing and BDA, which evolved from the assessment tools developed by and for artillerymen to determine damage done to enemy positions. Consequently, to understand the evolution of BDA World War I, we must look first at the role of artillery and its interaction with observation and spotting aircraft.

¹⁶ Sir W. Raleigh and H. A. Jones, *The War in the Air*, (London, 1922-1937), Vol. 2, 117-118, 131-134. The BDA report, at AIR 1/2266/209/70/18, is entitled "Report on bomb dropping carried out by the Royal Flying Corps between 4 a.m. and 5 a.m. today," Royal Flying Corps, 9 May 1915. None of the seven sorties scored direct hits, but according to the pilots, two were near misses. Given the propensity among aircrews, who were passing over the target quickly and often in the midst of an adrenaline rush as enemy anti-aircraft artillery (AAA) and machine guns sought to bring them down, to exaggerate their bombing performance, it appears as though all seven missions failed to do any serious damage.

¹⁷ Raleigh and Jones, *The War in the Air*, Vol. 4, Appendix XXVI; Vol. 2, 181-183 and Appendix VI.

¹⁸ *Ibid.*, Vol. 2, 133 and Vol. 4, 491. The greatest bomb weight dropped in a 24-hour period was 50 tons.

There is abundant evidence to suggest that senior officers viewed bombers as extensions of field artillery and looked askance at suggestions that they be employed in independent bombing campaigns. By mid-1915, despite the emergence of the first bombing directives, the British Army's official position on bombers was that "aerial attack has not proved to be a serious operation of war."¹⁹ The French arrived at similar conclusions. Consequently, Allied commanders, "disenchanted with bombing attacks far from the front line, gave priority to direct support on the Western Front."²⁰ In November 1916, Sir Douglas Haig, the senior British commander, told the War Office, "Long-range bombing as a means of defeating the enemy is entirely secondary... its results are comparatively unimportant."²¹ Yet in the years prior to these developments, bombers had already become an extension of artillery, striking tactical targets both within and beyond the range of friendly artillery, and it was here that the BDA process had its birth.²²

The idea of bombers as extensions of field artillery was well developed by the summer of 1917 and continued to exert a major influence on air operations for the rest of the war. Even with the renewed interest in bombers after the German bombing raids, strategic operations took a back seat to more traditional uses. The RFC statement of

¹⁹ Raleigh and Jones, *The War in the Air*, Vol. 2, 426-451.

²⁰ Overy, "Strategic Bombardment," 15.

²¹ Gen Sir Douglas Haig to War Office, Nov 1, 1916, *Documents Relating to the Naval Air Service*, 2 vols. (London: 1969), Vol. 1, 405-407. Cited in Overy, "Strategic Bombardment," Pages 336-337 of the same report recorded Lord Derby's hostile view of bombing in comments to the Joint Air War Committee on March 31, 1916: "Opinion has been misled by the air raids against towns, munitions factories, aerodromes, etc., which are really secondary operations..." Strategic bombardment was later "rescued" from decline after the German summer 1917 bombing offensive, which led directly to the Smuts Report, an independent RAF, and a quasi-strategic bombing campaign by the British Independent Force (IF), commanded by Major-General Hugh Trenchard. Details follow later in this chapter.

²² One of the conundrums raised by the employment of bombers as long-range artillery platforms was their much-inferior accuracy when compared to artillery. Bombers carried increasingly large bombs, which in part made up for this disparity, but it was only with the development of crude but effective bombsights after 1917 that aircraft became a potent bombardment threat beyond the range of friendly artillery.

duties for bombing squadrons included a requirement "to undertake long range offensive operations against Military or National objectives," but this was at the bottom of the list after "fighting in the air," "reconnaissance," and "bombing in connection with military operations."²³ This decision to give bombing in support of ground forces priority over strategic bombing reflects the overriding focus on the ground war, technological limitations that made strategic bombing appear ineffective and wasteful of scarce resources, and a predisposition throughout the war to treat bombers as mobile artillery.

American senior officers adopted the British view of bombers as extensions of field artillery. In his post-Armistice final report, Brigadier General Benjamin Foulois characterized Day Bombardment squadrons as "tactical aviation" assets, explicitly "leaving the strategical Air Service units until such time as the personnel and materiel become available." In fact, Foulois went so far as to change the name of Lt Col Edgar S. Gorrell's embryonic "Strategical Section" to "GHQ Air Service Reserve" in the summer of 1918 to drive home the point that all air units, including bomb squadrons, would be "synchronized and coordinated with the missions of the entire AEF." In other words, aerial bombardment's first purpose was support of the ground war, not a strategic campaign against German industry.²⁴ Consequently, even in the Meuse-Argonne offensive, the beginning of the last great Allied push in October 1918, bombers were viewed as highly mobile artillery, and the BDA techniques used to judge effectiveness came directly from the process for determining the effectiveness of artillery barrages.

²³ Neville Jones, *The Origins of Strategic Bombing* (London: William Kimber, 1973), 94.

²⁴ George K. Williams, "'The Shank of the Drill': Americans and Strategical Aviation in the Great War," *The Journal of Strategic Studies*, 19:3 (Sept. 1996), 409.

The evidence for this close tie between artillery barrages, aerial bombardment, and BDA is abundant. It appears as though employment of bombers as long-range artillery in the American Air Service came from observing the British and French experience as well as from a French bombing document, which AEF staff officers had copied.²⁵ The "Final Report of Chief of Air Service" notes that deep reconnaissance missions were first and foremost designed to collect information on the effects of friendly artillery fire.²⁶ In September 1917, Major Edgar S. Gorrell, who at the time was Chief, Strategic [Bombing] Section, Zone of the Advance, produced a staff paper focused on munitions for bombers. Significantly, he dwelt almost entirely on smaller bombs (20-50 pounds) for use against ground forces and field emplacements. The fact that the chief of the *strategic* aviation effort was spending his time writing staff papers about munitions used for *tactical* bombing of enemy ground forces is highly significant and indicative of the American and Allied focus on aircraft as artillery platforms.²⁷

The Americans learned their artillery damage assessment techniques from the British and French, both of whom honed these skills in preceding years. For the St. Mihiel offensive, the primary mission of bombers was "to destroy and harass the rear areas of the battlefield, and to attack military and industrial objectives beyond the range of artillery."²⁸ The emphasis was clearly on aircraft as tactical bombardment platforms and extensions of the American artillery barrage. A May 1918 GHQ Instruction on aerial observation for artillery noted that "among the duties assigned to observation squadrons

²⁵ Ibid., 412-413.

²⁶ "Final Report of Chief of Air Service, A.E.F.," in Maurer Maurer, ed. (referred to after this as MM), *The U.S. Air Service in World War I* (Washington D.C.: Office of Air Force History, 1978), Vol. 1, 41.

²⁷ AFHRA 248.222-100, Major Edgar S. Gorrell, "General Remarks on Bombing," 27 September 1917, 1.

²⁸ HQ Chief of Air Service, 1st Army, Circular No. 1, "Day Bombardment," 19 August 1918, in MM, Vol. 3, 44.

are the observation of precision fire for effect and...at the same time, reconnaissance and photography, to determine the effect produced.”²⁹ The instruction continued with a reminder that “all aerial observers...cooperate in obtaining information. This information is collected in each air unit by the intelligence officer attached, who communicates it at once to the Intelligence Section and the artillery information officer.”³⁰ The Air Service report on the Meuse-Argonne offensive also said “the artillery objectives for the first part of the offensive...were...photographed both before and after firing,” indicating the importance of obtaining useful photointelligence for construction of artillery and bomb damage assessments.³¹ This photointelligence gave branch intelligence officers the data they needed to assess damage done to enemy units. Once they had produced damage assessments for their squadrons’ sectors, they sent copies to the group and wing levels, where additional intelligence was added and the report forwarded to G-2 (Intelligence Directorate) at GHQ AEF.

The second purpose of this intelligence, once in the hands of the branch intelligence officer, was the provision of rapid (later known as first-phase) and fused intelligence reports containing photointelligence, sketches, and POW reports, to the artillery information officer and to higher echelons of command. The artillery officer used these reports to coordinate artillery and air attacks with specific field artillery units and bomb

²⁹ Because aircraft assigned to observation squadrons flew both observation and reconnaissance missions, a brief word is in order to differentiate the two. Observation missions generally involved observing the effects of friendly artillery fire and spotting (providing corrections) for it. Reconnaissance involved flying over the trenches or behind the lines to detect enemy troop movements and building or digging activities. Because observation aircraft were perennially in short supply, ground commanders very rarely allowed them to conduct post-strike reconnaissance for bombing missions, which they generally viewed as a waste of effort. References in this study to observation units will always use the term “observation” rather than “reconnaissance” since the latter was used to describe a mission or activity rather than a flying unit.

³⁰ GHQ AEF, “Aerial Observation for Artillery,” May 1918, in MM, Vol. 2, 181, 183.

³¹ “A Tactical History of the Air Service AEF,” in MM, Vol. 1, 275.

squadrons. These reports became “the basis for rough sketches in the air unit, provisional interpretation in the army corps, and subsequent incorporation in the battle maps. The destruction maps are also made up from them.”³²

These references to battle maps and destruction maps are crucial because they indicate a direct tie between artillery damage assessments and BDA and indeed a fusion of artillery and bomb damage reporting into common intelligence products. Battle maps, produced at corps and army headquarters, provided a graphic representation of the front, including enemy trenches and artillery positions. The destruction maps, crucial for their relationship to BDA, were compilations of the *effects* of artillery and air attacks on enemy units and emplacements, with special attention given to the destruction of enemy artillery positions. To use a term that came into use in World War II, the destruction maps were the artillery version of “bomb plots” used by photointerpreters to assess bomb damage. A postwar Army report summed up this relationship between intelligence and artillery: “The artillery information service and G-2 have always cooperated and, as experience was gained, this cooperation became increasingly beneficial.”³³

The development of ideas and doctrine for bombing in 1914-18 represented what might be described as a nonlinear evolution. Initially, bombers evolved as long-range, highly-mobile artillery, a function they have retained in the close-air-support and battle-area interdiction roles. This changed in 1917-18, as the Germans and British bombed each other’s cities, and as the British and Americans began employing bombers against

³² GHQ AEF, “Aerial Observation for Artillery,” May 1918, in MM, Vol. 2, 182.

³³ Historical Division, Department of the Army, Washington D.C., 1948, *The United States Army in the World War 1917-1919*, Reports of the Commander-in-Chief, A.E.F., Staff Sections and Services, Part II (Vol. 13): (Brigadier General D. E. Nolan, G-2, G.S.), 11.

“deep” targets such as marshalling yards, airdromes, supply depots, and factories. These new forms of bombing were forerunners of what came to be called *strategic bombing* during World War II. They required new technicians, analytical tools, and techniques to determine bombing’s effects and effectiveness. The key result of this development was the birth of BDA as a systematic and distinct intelligence discipline.

2.3 BDA and the First British Strategic Bombing Campaign

The first bombing campaign that can be considered strategic in its aims occurred in 1916, when the RNAS and French Army bomber squadrons engaged in a minor effort to impede the German war effort by attacking industrial targets and drawing fighters from the front lines to protect German industry. This air offensive was hampered by a severe shortage of pilots and machines, and by the continued absence of onboard cameras for strike photos.³⁴ The only bright spot was the attention the French air staff gave to target selection and BDA. French staff planners, in conjunction with their British counterparts, developed a list of targets, including steel furnaces and arms plants, according to their importance in supporting the German war effort. They then ascertained whether each objective was in range and vulnerable to air attack. Finally, they assigned an order of priority based on the feasibility of damaging or destroying each target.³⁵ However, this first effort at systematic targeting for a bombing campaign is a key reminder that target

³⁴ See AIR 1/2266/209/70/18, Admiralty, M.O.I.c, “Notes on Report of Bombing Operations of No. 3 Wing R.N.A.S. in France during Winter 1916/1917,” 15 October 1917, 1-2. At the height of this air offensive, No. 3 Wing, RNAS (also referred to as the “Luxeuil Wing” in reference to the location of its home airfield), had on average only 43 pilots each month to fly 74 available aircraft.

³⁵ AIR 1/508/16/3/52, “Report of Aviation Conference,” 4 July 1916. This priority-ordered target list stands in stark contrast to British target lists late in the war, when Trenchard commanded the RAF’s Independent Force (IF). His target lists were not priority-ordered, nor were they based on any systematic methodology or target-systems approach. Trenchard’s preoccupation with morale effects was at the heart of this problem.

selection is only half of the equation; the other half is being able to judge bombing effects and effectiveness. The British and French were not prepared to do this in 1916.

The campaign began in summer 1916 and deteriorated rapidly due to high losses, aircraft shortages, and bad weather.³⁶ One of the biggest problems was the inability to get reliable damage reports. When bombers attacked enemy troop concentrations or artillery near the front, they usually did so in conjunction with friendly artillery barrages, and the results showed up on reconnaissance photos taken of the effects of artillery on the enemy's positions, even if the craters made by bombs were difficult to distinguish from those made by artillery. However, once the Allies began bombing targets beyond the range of artillery, as during this effort, they had to rely on aircrew observations since ground commanders, who at this point had tasking authority over observation squadrons, very rarely allocated their scarce reconnaissance assets to independent bombing missions, which most of them considered a waste of effort. The results for BDA were predictable: Intelligence officers relied on aircrew reports until November 1917, when one British bomber per squadron began carrying a camera to record bombing results.³⁷

A British raid by No. 3 Wing of the RNAS on the Mauser arms factory at Oberndorf on 12 October 1916 was typical of BDA shortfalls during this bombing campaign.

Aircrews briefed "unreported results" after the mission, British and German

³⁶ AIR 1/2266/209/70/18, Admiralty, M.O.I.c, "Notes on Report of Bombing Operations of No. 3 Wing R.N.A.S. in France during Winter 1916/1917," 15 October 1917, 1-2. No. 3 Squadron carried out only 13 raids from July 1916 to April 1917, with an average of 1.8 effective flights per aircraft during the entire campaign. Aircrews dropped a total of 14.5 tons of bombs, with the average aircraft dropping 236 pounds of bombs during the entire campaign. These figures demonstrate how difficult it was for the rudimentary bombers employed in this campaign to operate effectively in view of weather, maintenance problems, and the severe pilot shortage mentioned in note 34.

³⁷ BDA reports from Lieutenant Colonel C. L. N. Newall, Commander, 41st Wing, RFC, are the first to note specifically that aircraft participating in the raids had cameras aboard for obtaining strike photographs. See, for instance, AIR 1/2266/209/70/18, "Detailed Report on Bomb Raid Carried Out during the Day—6th December 1917," which notes that "A total of 38 plates were exposed, the results of which are good."

communiqués and press reports were at odds with one another with regard to damage done to the target, and no post-strike aerial reconnaissance was ordered as a result of bombing's low priority. The only bright spot in this particular case was a report provided by an escaped French prisoner of war who was working at the plant during the British raid, in which he stated that damage to the factory was "much more considerable than first reported, [and] the new Works which prisoners were building suffering severely." On the down side, he noted that several of the bombers involved in the raid missed the plant altogether, dropping their bombs on factories in adjacent towns.³⁸ Aircrews also claimed "direct hits on the blast furnaces" during a raid on the Thyssen steel works at Hagendingen during the same month, a claim corroborated by French intelligence sources. In fact, three of the five blast furnaces had been destroyed in this unusually effective raid.³⁹ On November 10 and 11, bombers attacked the iron works at Völklingen, again claiming direct hits. Once again, French intelligence sources claimed that serious damage was done by the raids, but the absence of post-strike photography and trained photointerpreters to determine the extent of the damage meant BDA was essentially inspired guesswork based on often-exaggerated aircrew and agent reports.⁴⁰ This tendency to overstate results had its genesis in three problems alluded to earlier: a lack of cameras on bombers to collect strike photos, a lack of reconnaissance aircraft to collect post-strike BDA, and the small and ineffective bombs then available. It was only after

³⁸ These reports are all in AIR 1/111/15/39/1 and were produced between 12 and 21 October 1916. The French PW's report is in AIR 1/2266/209/70/18, "Summary of Raids Carried Out by No. 3 Wing, R.N.A.S., between 30th July 1916 and 14th April 1917," Summary No. 2.

³⁹ Ibid., reports produced between 23 October and 6 December 1916. The French intelligence report, which was probably based on information from an agent, is in AIR 1/2266/209/70/18, "Summary of Raids Carried Out by No. 3 Wing, R.N.A.S., between 30th July 1916 and 14th April 1917," Summary No. 3.

⁴⁰ The French intelligence report is in AIR 1/2266/209/70/18, "Summary of Raids Carried Out by No. 3 Wing, R.N.A.S., between 30th July 1916 and 14th April 1917," Summaries No. 4 and 5.

the war, as a result of data gathered by British and American postwar bombing surveys, that it became clear how badly most wartime BDA reports overstated damage.

For instance, although the postwar surveys indicate that British bombing caused a shortfall in steel production of 1,714 tons at Völkingen in November 1916, and damages totaling 42,000 marks, the effect on the plant's war production was minor, and the impact on the German war economy negligible. In addition, it only became clear after the war that the Germans had built concrete walls between each piece of equipment in the factory and a concrete false ceiling over the main building. Bombs had to get through the false ceiling without exploding prematurely—which most did not—and even then were able to destroy only a single piece of machinery even with a direct hit, due to the small size of bombs and excellent German protective measures. These would have been spotted by British photointerpreters during World War II but were impossible to find in 1916 due to the lack of cameras on bombers, a scarcity of reconnaissance assets, and the poor quality of cameras and photographic paper in 1916.⁴¹ Consequently, as one scholar has noted,

the means for estimating material damage and morale effect during hostilities were necessarily fragmentary and often contradictory. The indicators needed to evaluate the campaign's effectiveness were largely unavailable to the Allied air staffs. Without the *required* indicators, such as post-strike photographs and access to enemy industrial records, British and French planners had to rely upon *available* indicators (aircrew observations, captured letters, agents' reports, and articles/editorials in German periodicals) to judge the results of bombing...⁴²

Of course, aircrew reports tended to be inflated and fragmentary, while captured letters, agents' reports, and articles from German periodicals provided only occasional

⁴¹ American postwar bombing survey, in MM, Vol. 4, 441-444. The quality of aerial photographs was a crucial factor in limiting BDA effectiveness during World War I because the granularity of existing photographic paper was too large until nearly the end of the war. The development of silver-mercury-based paper by the Kodak Company allowed for much-improved aerial photographs.

⁴² Williams, *Biplanes and Bombsights*, 15-16.

(and often purposely misleading) insights. Although strike photos of bombing raids became more widely available once the British and Americans began putting cameras on their bombers in the fall of 1917, a scarcity of reconnaissance aircraft for post-strike missions persisted until the end of the war. This first strategic bombing effort did not have the desired effects of reducing German war production appreciably and forcing the Germans to redeploy large numbers of fighters, nor would the British have been able to make an educated assessment either way given the shortage of BDA assets.⁴³

The poor results of this effort, combined with a dramatic series of changes in the air situation that included the arrival of new German fighters and the British loss of air superiority along most of the front, led British policymakers and military leaders to call it off at the end of March 1917. No. 3 Wing was then disbanded in May. Field Marshal Sir Douglas Haig played a crucial role in this process, and among the after-action reports produced for this air offensive was the conclusion that “long-distance bombing as a means of defeating the enemy is entirely secondary to...[Army] requirements: its success is far more doubtful and, even when successful, both theory and practice go to show that usually its results are comparatively unimportant.”⁴⁴ This state of affairs might have persisted until the end of the war had the Germans not engaged in their own bombing campaign against Britain, creating popular demand for a renewed bombing of Germany.

2.4 German Bombing, the Smuts Report, and the Creation of the RAF and IF

The British bombing effort, well on its way to oblivion in the summer of 1917, received a new lease on life when German Gotha and Giant bomber raids on England

⁴³ AIR 2/123, memo, Lord George Nathaniel Curzon [in his capacity as chairman of the Air Board] to War Committee, 9 November 1916.

⁴⁴ Raleigh and Jones, *The War in the Air*, Vol. 6, 122.

drove the British public to demand reprisal bombing of Germany. As one author notes, "the raids had an impact disproportionate to the bomb load they carried," which totaled 7.5 tons.⁴⁵ There was no panic, but there was anger, and Parliament sought to address the public's grievances. The German raids sparked a renewed interest in bombing as a retaliatory and strategic weapon. Lord George Curzon, head of the British Air Board established in the wake of the German attacks, told the War Cabinet that "we do not recede from the view that a long-range offensive is in itself a most desirable thing and should be systematically pursued when the force is available for the purpose."⁴⁶ The results of German bombing, based on recommendations in the Smuts Report, included significant changes in air organization and the birth of the RAF on 1 April 1918.⁴⁷

The Smuts Report called for the creation of a bombing wing, under independent field command, to carry out reprisal and strategic attacks. Although strategic attacks proved to be the exception rather than the rule, the Independent Force (IF) and its predecessors, the 41st Wing and 8th Brigade, began bombing raids against German industrial and urban targets in October 1917. From its moribund state after the failure of the combined RNAS-French bombing campaign in 1916-17, strategic bombing as a concept and an operational reality rose like a phoenix from its own ashes to play a modest but increasing role in the war's final campaigns. Despite its billing as a "strategic" bombing campaign, the effort was largely tactical in nature, due to the fact that Major-General Trenchard,

⁴⁵ Tami Davis Biddle, *Rhetoric and Reality in Air Warfare: The Evolution of British and American Ideas About Strategic Bombing, 1914-1945* (Princeton, NJ: Princeton University Press, 2002), 30.

⁴⁶ Memo, Lord Curzon for the War Committee, "Long-range Bombing Operations by Aircraft," November 9, 1916, *Documents Relating to the Naval Air Service*, 2 vols. (London: 1969), Vol. 1, 420.

⁴⁷ Biddle, *Rhetoric and Reality*, 30-32. The Smuts Report was named for Jan Smuts, South African soldier and statesman, who chaired the board, convened in response to the German bombing, which called for creation of the RAF.

General Officer Commanding, IF, focused on airdromes and marshalling yards, which he saw as more valuable targets than German industry. Given the limited capabilities of bombers *at the time*, Trenchard may have been right. Unfortunately, he also showed a disregard for BDA, choosing to focus on morale effects. His assertion, that “the moral effect of bombing stands undoubtedly to the material in proportion of 20 to 1”⁴⁸ simply had no basis in fact. It was a myth the Air Ministry perpetuated after the war, with serious consequences for the subsequent development of bombing doctrine and BDA.

British bombing began again with deployment of 41st Wing in October 1917 and continued after the unit was renamed the 8th Brigade in February 1918 and then subsumed within the IF in June 1918. The purpose was twofold: reprisals for German bombing of Britain and a vaguely-defined “strategic” air campaign to undermine German workers’ morale and thereby cause a collapse in the German war effort. Brigadier General Cyril Newall, the 41st Wing commander, proposed attacking vital industries systematically as more bombers became available, and the Air Ministry agreed.⁴⁹ As will become clear later, however, Trenchard had other ideas about proper employment of the IF. In any case, the reemergence of British bombing drove the development of a rudimentary intellectual infrastructure for BDA by the closing months of 1917.

2.5 The Development of an Intellectual Infrastructure for BDA

The most important results of the “Gotha Summer” for the development of BDA have to do with the realization that a sustained bombing campaign, regardless of its focus,

⁴⁸ AIR 6/19, Major General Hugh M. Trenchard, Dispatch, Dec. 12, 1918; and Dispatch, Jan. 1, 1919, reprinted in *Aeroplane*, 8 January 1919, 129-131.

⁴⁹ AIR 1/460/15/312/101, “The Scientific and Methodical Attack of Vital Industries,” 27 May 1918, 5; Williams, *Biplanes and Bombsights*, 35. Newall’s plan was based on an earlier one developed by Major Lord Tiverton, which receives detailed attention later in this chapter and in the next chapter.

would require at least a basic ability to assess its effects and effectiveness over time. Consequently, the British established intelligence and photographic sections in their bomber units in the autumn of 1917, an effort the Americans copied. These capabilities interacted with the formation of British and American air staffs, training for intelligence and photographic officers, and new technologies to produce a nascent BDA intellectual infrastructure by 1918. The technological aspects of this process were already evolving.

2.51 Technological Advances

The key technologies included reconnaissance aircraft, cameras, and facilities for the rapid development of photographs; and optical devices for viewing the photos. They were put to use by a new breed of airmen, including photographic and air intelligence officers to develop and interpret photos, fuse the insights thus gleaned with intelligence from other sources, and produce "raid reports" for aircrews and senior officers who required them to plan, execute, and assess bombing raids. By the fall of 1917, the major belligerents on the Western Front were taking over 8,000 pictures daily, many of which were used to conduct artillery damage assessment and BDA. As better pursuit aircraft drove reconnaissance aircraft to higher altitudes, a reciprocal process developed in which higher operational altitudes forced the development of improved cameras, better film, and bromide photographic paper with superior granularity (smaller grains allowed for higher-resolution photographs). Frigid temperatures also drove development of electric and engine-exhaust heating systems to keep cameras, plates, and film from freezing.⁵⁰

Cameras, though increasingly capable as the war continued, remained large, cumbersome, and labor-intensive. Camera lenses ranged in size from 8.5 to 40 inches of

⁵⁰ Stanley, *World War II Photo Intelligence*, 26.

focal length, with the 20-inch lens becoming most popular by 1916. British and French cameras produced negatives of 4-by-5 inches and 7x9.5 inches, used plates rather than film (a drawback in terms of numbers of exposures per mission and weight of the camera, but advantageous for yielding more detailed images), required manual operation (unlike German cameras after 1916, which were automatic and used film), and were either hand-held or attached to the side of the aircraft. The heavier and more labor-intensive Allied cameras also required bigger aircraft with two-man crews.⁵¹

The fact that the bombers themselves lacked cameras to record the results of missions in progress also indicated the minor emphasis on BDA until the British began equipping a small percentage of their bombers with cameras in November 1917 to record mission results during bombing raids.⁵² As late as September 1918, an American Expeditionary Forces (AEF) telegram reminded the Army's assistant chief of supply that all observation aircraft should be equipped with cameras for vertical and oblique photography, and radios for tactical communications.⁵³ Days later another plaintive telegram said, "it is absolutely necessary that fifteen percent of all observation planes and five percent of all bombing planes delivered to the ZOA [zone of operations] should be equipped for photography," a clear indication of aerial photography's importance and the scarcity of aircraft—especially bombers—equipped with cameras.⁵⁴

By late 1917 the American photographic effort, modeled on the British, was well advanced. Photographic matters came under the purview of the Photographic Section of

⁵¹ Ibid., 26-29.

⁵² AIR 1/2266/209/70/18, Capt Elder; AIR 1/2104/207/36, "Results of Air Raids on Germany Carried Out by the 8th Brigade and the Independent Force, RAF, January 1-November 11, 1918."

⁵³ AFHRA 167.403-183, Cable, Foulois to Asst. Chief of Supply Section, 13 September 1918.

⁵⁴ AFHRA 167.403-214, Cable, Foulois to Asst. Chief of Supply Section, 19 September 1918.

the Air Service. The attention given to aerial photography had its genesis in Congressional hearings on military funds in January 1917, during which an Air Service officer emphasized that cameras were of crucial importance to flying operations and should be standard equipment in all aircraft groups and squadrons, noting in particular their roles in reconnaissance and fire control. Despite the high priority it received, the Photographic Section faced many challenges, including too few trained officers and low-quality bromide paper and plates. The paper problem was particularly serious because supplies available in Europe were of low quality and produced very granular photographs. American ingenuity came to the rescue, however, when the Eastman Kodak Company opened a bromide paper factory in Paris in late 1917. As a result, the quality of photographs showed "an improvement of at least 50 percent."⁵⁵

In April 1918, the Photographic Section also developed a standardized equipment list for all photographic sections assigned to headquarters and flying units. This allowed for rapid supply and re-supply of cameras and photographic materials. It also facilitated the purchase of improved equipment, including the French-built De Ram automatic plate camera, which went into service with U.S. forces in August 1917. It allowed for a great increase in the number of usable images taken during a single mission because its 50 plates moved automatically each time the camera's automatic shutter snapped a picture. This allowed observers to look for landmarks and enemy aircraft rather than changing each plate manually. The creation of an inter-Allied board for photographic matters helped the Americans to overcome equipment shortages by late 1917. A key example

⁵⁵ "Final Report of the Chief of Air Service, AFE," in MM, Vol. 1, 59, 63, 151; "Funds for Fiscal Year 1918," in MM, Vol. 2, 97-99.

was the board's request that the French *Service Geographique* produce enough camera lenses for French *and* American units, a request the office honored.⁵⁶

As photographic equipment improved, so did bombs, which by definition played a central role in BDA and MEA. In fact, bombs, cameras, and the other technologies related to the BDA process became integral parts of a self-reinforcing targeting-bombing-assessment feedback loop in which intelligence officers and aircrews incorporated lessons learned in previous missions, and also from the RDTE process for bombs and related hardware, into BDA for recent missions. Consequently, it is impossible to discuss the evolution of BDA without looking at the other key components of the BDA process: bombs, fuses, bomb release mechanisms, and bombsights.

Initially, state arsenals had no purpose-built bombs, but they did have huge numbers of artillery shells in the 75 to 120 mm range, many of which they turned into *ad hoc* aerial munitions by adding tail fins. Private manufacturers actually took the lead, designing and producing the first purpose-built bombs just before the war began.⁵⁷ Most early bombs were small, weighing between 20 and 110 pounds, and had primitive fuses prone to malfunction. The results, as early MEA efforts confirmed in 1915-16, were inadequate destructive power, poor ballistic qualities (hence poor accuracy), and high malfunction rates. Even direct hits, when they did occur, tended to do little damage, especially to large buildings made of brick or concrete.

British efforts to determine munitions effectiveness received their greatest impetus from German bombing raids against Britain in 1917, which spurred British intelligence

⁵⁶ "Final Report of the Chief of Air Service, AFE," in MM, Vol. 1, 151-154.

⁵⁷ Kennett, *The First Air War*, 47.

and ordnance officers to look at the effects of German bombs for the purpose of improving their own munitions. The largest German high-explosive bomb, which weighed 300 kg. (660 lbs.), did severe damage to concrete and brick structures. One of these weapons destroyed a two-storey shop and four houses, blew in the front walls and tore the roofs off of five houses across the street, and caused severe damage to the roofs and glass of all structures within 150 yards. Another penetrated the roof of a four-storey building, detonated at ground level, and destroyed it entirely. These large bombs produced craters 30 feet in diameter and 15 feet in depth.⁵⁸

The report also noted the inferior results produced by 100-kg. (220-lb.) high-explosive bombs dropped during the same series of raids. One such bomb fell directly adjacent to a railway line built on brick arches and blew out 42 feet of the retaining wall next to the arches but failed to do any damage to the arches or the tracks. Two other bombs fell on row houses and destroyed only the houses they hit and those immediately adjacent. The effect on multistory buildings was also noticeably less: a bomb dropped on a six-storey building destroyed the top two floors and damaged the third, but the bottom half of the building was untouched.⁵⁹ The lessons of this MEA were clear: For attacks on industrial or urban targets, larger bombs caused much greater damage. In fact, the damage was well out of proportion to the size differential.⁶⁰

The British postwar bombing survey substantiated these insights. Records of an attack on the Thyssen steel furnaces demonstrate how post-strike assessments, based on aircrew reports, differed from German damage reports on the same targets. German

⁵⁸ AFHRA 248.6282-7A, "Report on Bombs Dropped in the Metropolitan Area," no author listed, 1 June 1918, 1.

⁵⁹ Ibid., 2.

⁶⁰ In other words, the larger bombs were more effective *pound for pound* than smaller munitions.

reports showed accurate bombing in this case but also emphasized the minor damage caused by the 30-kg. (66-lb.) bombs the British dropped on the facility. In fact, the German reports note how ineffective small bombs (60-kg. [112-lb.] or smaller) were against heavy machinery. Even if they penetrated the ceiling and scored a direct hit on machinery, they damaged it only slightly. The Germans also observed that 25 percent of bombs dropped on this target were duds, about the average for this period.⁶¹

By the autumn of 1917, British and American airmen were calling for larger bombs. In fact, RNAS Raid Summaries indicate that airmen were already making the move to larger weapons between the fall of 1916 and the summer of 1917. RNAS bombers dropped 700 bombs between 10 and 28 November 1916. Of these, 503 were either 22-lb. or 16-lb. weapons, which in most cases did little or no appreciable damage. Of the remainder, 172 were 65-lb. bombs and another 24 were 100-lb. weapons. Only one 520-lb. bomb was dropped during this period. This contrasted markedly with the 244 bombs dropped between 13 and 22 July 1917, which included one 550-lb. and two 520-lb. bombs. Another 141 were 112-lb. weapons, and 53 were of the 65-lb. variety. Only 12 16-lb. bombs were dropped, and no 22-lb. weapons at all. The shift to larger bombs was rapid after the summer of 1916, in the RNAS and RFC/RAF, as a four-way interaction developed between Allied aircrews, who sought larger weapons as the ineffectiveness of small ones became evident; the Germans, who built increasingly hardened installations as the war progressed; aircraft and bomb manufacturers, who sought to provide aircraft with larger payloads and bigger bombs to attack these installations; and the Air Board, the

⁶¹ American postwar bombing survey, in MM, Vol. 4, 386-387; AIR 1/111/15/39/1, Official Raid Reports; AIR 1/1998/204/273/266, Major H. Paul, RAF in the field, to Air Ministry, "Reports as to the Effect of Various Types of Bombs on Buildings, Streets, etc., and General Conclusions," 26 February 1919.

Bombing Committee, the Admiralty, and (after 1 April 1918) the Air Ministry, all of which recognized the need for bigger bombs, better fuses, and bomb-dropping mechanisms to handle larger weapons.⁶²

In response to entreaties from airmen, the Bombing Committee, responsible for development of improved munitions, sought a doubling in the production of 230-lb. bombs because the new Handley Page O/400 bomber was able to carry eight of them. For comparative purposes, the DH-9 bomber, the mainstay of the force in the fall of 1917, carried only two. The committee also called for an increase in the production of 112-lb. bombs from 10,000 to 12,000 per week. A few weeks later, the committee asked the Air Board to purchase 1,000 each of the experimental 1,650-lb. and 700-lb. bombs, both of which were designed to knock out hardened structures such as factories and U-boat berths. A bomber pilot who dropped one of the first 700-lb. bombs was awed by its destructive power, saying it had caused four- and five-storey houses "to disappear entirely." Topping off this interest in larger bombs was an initiative to introduce long-delay fuses, which allowed bombs to explode anywhere from several hours to several days after they were dropped, to interfere with German debris-clearance and repairs.⁶³

Similarly, the officers and men of the Bomb Unit, Engineering Branch, U.S. Army Ordnance Department, were responsible for turning such requirements into improved

⁶² AIR 1/271/15/226/118, RNAS Raid Summaries for 10-28 November 1916 and 13-22 July 1917. AIR 1/343/15/226/282, "Report of the Effect of Bombing by the Late Royal Naval Air Service and 5th Group Units with Relation to Enemy Submarine Activity on the Belgian Coast," Appendix 1, November 1918, makes clear the interaction between German efforts to improve their U-boat shelters at Bruges and Zeebrugge and the RNAS shift to larger bombs. This interaction intensified after 1916.

⁶³ AIR 1/460/15/312/101, Air Board, proposal to order additional bombs, 30 November 1917; Air Board, "Proposal to order 1000 - 1650 lb. bombs," December 1917; Air Board, "Long Delay Action Fuse," November 1917. For aircraft bomb loads, see *Air Power: A Modern Illustrated History* (New York: Exeter Books, 1979), 215 and 223, for bomb loads and other information on these bombers.

munitions for American bomb squadrons.⁶⁴ This organization produced several technical reports that trace the development of MEA-related capabilities in three important ways. First, they recorded a demand for larger bombs. Second, they demonstrated the increasing sophistication of bomb manufacture, including bomb casings, fuses, explosive materials, and fins. Third, they illustrated the problems involved in the development of incendiary bombs, which caused much aggravation and never evolved into reliable weapons until the Second World War.

The increasing size of American munitions in 1917 paralleled the trend in British bombs and marked a basic point of departure in terms of the bombs themselves and the kinds of targets bomber crews had begun attacking by 1917, including marshalling yards, bridges, and industrial facilities, all of which required larger munitions. American bomb designs rested initially on three French models, the Mark I, II, and III, which weighed 105, 25, and 55 pounds. In July 1917, when the Ordnance Department adopted these bombs, the 105-lb. weapon was considered effective for demolition purposes, while the 55-lb. bomb was employed as either a demolition or fragmentation (anti-personnel) bomb and the 25-lb. bomb was an anti-personnel weapon.⁶⁵ By the time testing began on these standard types in late 1917, an improved explosive, known as amatol, was functioning perfectly in munitions tests. Other improvements included removal of the lead safety pin from the bombs, which increased their reliability from around 80 percent to well over 90 percent, and the use of pointed firing pins, which also added reliability.⁶⁶

⁶⁴ "Final Report of the Chief of Air Service, AEF," in MM, Vol. 1, 147.

⁶⁵ AFHRA 289.9201, Bomb Unit of the Engineering Branch, Ordnance Department, "A History of Bombs: High Capacity Drop Bombs, Marks I, II and III," n.d. (probably 1919), 2-3.

⁶⁶ Ibid., 5, 8-9.

On 29 May 1918, an AEF telegram informed the Ordnance Department that the Mark II bomb was too small and should be discontinued.⁶⁷ Similarly, the 50-pound bomb was now seen as too small for demolition work but still useful for softer targets such as marshalling yards, where the cratering effect was sufficient, and against personnel, where the fragmentation version worked well.⁶⁸ These insights came from MEA conducted by intelligence and ordnance officers.

By 1918 there was general agreement that bigger bombs were better when cratering effects and demolition were desired. The requirement for larger bombs emerged in December 1917, when the Department of Aircraft Production sent the Ordnance Department a request for three new bombs, based on British designs. These became known as the Mark IV, V, and VI, weighing 250, 550, and 1,000 pounds. Two telegrams from the AEF in February 1918 reiterated the requirement for these bombs. The sheer size of these new weapons created a number of development, testing, and production problems. Greatest among these was the initial lack of any aircraft large enough to carry the bombs for testing purposes; the expense of test firings, which drove the Army to develop drop towers from which the weapons were tested; and the importance of high-quality, single-body construction, which gave manufacturers trouble until late 1918.⁶⁹

The degree to which the evolution of aerial bombardment in the latter stages of World War I drove the development of bigger bombs is clear. Both British and American aerial bombardment efforts were by this time focusing increasingly on industrial and

⁶⁷ Ibid., 9.

⁶⁸ Ibid., 13.

⁶⁹ AFHRA 289.9201, Bomb Unit of the Engineering Branch, Ordnance Department, "A History of Bombs: History of the Development of the Mark IV, V and VI Demolition Drop Bombs," n.d. (probably 1919), 3-4.

railroad targets beyond the range of artillery. A cablegram from HQ AEF to the Ordnance Department, dated 15 June 1918, said

Present tendency is toward penetration bomb with center of gravity and greatest diameter at nose and heavy rear casing to give deep penetration of high building...request early penetration test of American 100-lb. and 250-lb. bomb by dropping bombs filled with inert substances on test buildings having substantial roofs and at least four floors.⁷⁰

A June 1918 AEF cablegram followed with an urgent request for development of a full range of delay, instantaneous, nose, and tail fuses for a variety of uses, including demolition of large, multistory buildings. Insights gleaned from British air officers with experience in bomb development also led American designers to produce both thin-walled versions of the large bombs, to maximize the cratering effects against softer targets such as railroads and marshalling yards, and thick-walled versions with delay fuses to penetrate deep into industrial facilities and destroy machinery with both blast and fragmentation effects. Tests conducted on the full range of American bombs demonstrated the huge difference in cratering effects between the first generation of small bombs and the second generation of larger ones. The Mark II 25-pound bomb, for instance, with 11 pounds of explosive, produced a crater eight feet in diameter and four feet deep, while the Mark VI 1,000-pound bomb, with 550 pounds of explosive, yielded a crater 45 feet in diameter and 18 feet deep in the same soil type, a truly staggering difference with obvious implications for bombing industrial and railroad target sets.⁷¹

Although these reports were not yet available when Major Edgar S. Gorrell arrived in France in summer 1917, he had already begun looking closely at bombs, bombsights,

⁷⁰ Ibid., 4-5.

⁷¹ Ibid., 4-7.

bomb release mechanisms, and other factors influencing the effectiveness of British and French bombing. His insights, in a memo to the Chief Signal Officer (the Air Service was subordinate to the Signal Corps in World War I), are based on insights gleaned from discussions with British and French airmen. They were used by the Army's Ordnance Bureau and industry to design and produce better bombs. Gorrell's memo provides a unique look at the state of bombing and BDA as the Americans began arriving in France.

To highlight the issue of aircrew training, Gorrell said

bomb-dropping by daylight is impossible without formation flying, so simultaneously with teaching bomb-dropping the pilots must be taught formation flying...because... delays on the part of any one or two pilots delay the whole squadron, and break up the general time schedule necessary for the success of the bomb-dropping raid.⁷²

Gorrell did not mention that only one bomber in six received bombsights due to their scarcity, making formation bombing a requirement in any case.⁷³ Finally, Gorrell said,

the system coming into general use here, is for the observer [rather than the pilot] to drop the bombs...all in Europe are now admitting that it is out of the question for the pilot to also be the bomb-dropper when one is seeking for accurate bombing. The observer can drop the bombs with great precision, and he has plenty of time to watch his sights, and use his stop watch.⁷⁴

Clearly, Gorrell understood that bombing effectiveness rested as much on aircrew competence as on good equipment. The targeting-bombing-assessment feedback loop thus included not only BDA strictly defined, but the full range of bombing-related

⁷² Gorrell, "General Remarks on Bombing," 3.

⁷³ AFHRA 167.403.213, Cable, Foulois to Signal Corps, United States Army, 22 August 1918.

⁷⁴ Gorrell, "General Remarks on Bombing," 3. The "lead navigator" concept is also noted in the "Provisional Manual of Operations for Air Service Units, MM, Vol. 2, 278-279: "Greater accuracy is obtained by permitting the leading observer to sight for the whole formation. Accurate bombing is an art in which certain observers will excel, and these observers should be used as leaders and deputy leaders." The lead observer knows the rest of the formation is "watching his back" and thus aims more accurately. The leader fires a signal, "prepare to drop bombs," and once bombs start to leave the racks, the rest of the aircraft drop their bombs."

activities, including conducting effective targeting; loading aircraft with the proper weapons, properly fused; getting aircraft over the target and dropping weapons accurately; and finally getting aerial photographs and other intelligence to gauge bombing effects and effectiveness.

2.52 Organizational and Training Improvements

The requirement for increasingly detailed BDA resulted in organizational and training improvements as well as the technological advances just discussed. In fact, all three were so intertwined as to be effectively conjoined. By 1918, reconnaissance and observation aircraft routinely carried cameras, while a small number (5-10 percent) of bombers carried them for the purpose of augmenting aircrew debriefings with strike photos acquired during bombing raids. This required photographic and intelligence sections at each bombardment squadron, an initiative that took months to complete as officers moved through newly-established training pipelines to the various squadrons. In these new duty sections, BDA began to develop as a distinct activity. Not only were photographic and intelligence officers focused on bombing effects and effectiveness; they also learned to interpret photographs of a new sort that depicted not trench lines and the results of artillery barrages, but rather the effects of bombs on railroads, marshalling yards, supply depots, industrial facilities, airdromes, and other targets beyond the range of friendly artillery. This involved new skills that developed rapidly as the number of bombing missions increased dramatically in the final months of the war. New tools such as stereoscopic viewing devices and workstations with bright lights to bring out the contrasts and shadowing in aerial photographs, also allowed for better BDA.

By fall 1917, the British Intelligence School was up and running. The Americans followed suit in July 1918, with the creation of the American Army Intelligence School in Langres.⁷⁵ Before these training centers were established, intelligence officers had received no formal instruction in the tools and techniques of air intelligence. Whatever training they received was on the job rather than in the classroom. Although none of the courses focused specifically on duties unique to air intelligence such as BDA, air orders of battle, and enemy air defenses, they all devoted significant attention to the question of interpreting aerial photographs, primarily for the purposes of mapping and building photo mosaics of the trench lines, but also to develop the skills photointerpreters needed to coax useful intelligence from those photographs. The basic photointerpretation skills officers learned at the intelligence schools helped them to assess the results of bombing raids and work more effectively with the officers of the photographic sections.

Formal training for photographic officers developed earlier, with schools open by the end of 1915. American photographic personnel learned the tools of their trade at Cornell University, Langley Field, Virginia, and at the Eastman Kodak factory in Brooklyn. They also received advanced training in Tours France, where the Aerial Photographic Center brought American airmen and photographic officers up to date on the latest British and French capabilities.⁷⁶ By the time Americans began arriving in France, British and French photographic officers were also becoming *de facto* photointerpreters, a subspecialty not foreseen when the war began but one in great demand by late 1917.

⁷⁵ Historical Division, Department of the Army, Washington D.C., 1948, *The United States Army in the World War 1917-1919*, Reports of the Commander-in-Chief, A.E.F., Staff Sections and Services, Part II (Vol. 13): (Brigadier General D. E. Nolan, G-2, G.S.), 11.

⁷⁶ *Ibid.*, 26.

They often shared this function with intelligence officers at flying units, who were responsible for interpreting aerial photos but often lacked the skills to do so.

Photographic officers assigned to flying units, aside from introducing stereoscopes, improved cameras, and other BDA-related gear, commanded the photographic section. They were in charge of the unit's photographic equipment, supervised the installation of cameras aboard aircraft, and oversaw the development and printing of photographs.⁷⁷

In 1918, the French Army General Headquarters of the Armies of the North and Northeast published a handbook, entitled *Study and Exploitation of Aerial Photographs*, illustrating the major advances in photo interpretation and, by extension, BDA. This foundational document, translated into English, influenced British and American BDA development. One of its crucial conclusions was that "the study of aerial photographs must be entrusted to specialists, who should be provided with all possible means of verification." This reference was not just to photointerpreters *in general* as specialists, but rather a recognition that *specific subspecialties* of photointerpreters had emerged by 1918, several of which focused entirely on assessing, in conjunction with air intelligence officers, the effects and effectiveness of aerial bombardment. These photointerpreters divided their craft into three phases: interpretation, restitution, and exploitation. The former involved a first-stage interpretation at the unit level, which included integration of BDA photos with other sources, such as POW reports and aircrew debriefings, in an initial effort to determine damage done to the target. From there, first-phase intelligence reports went up the chain for second-phase interpretation and reporting at headquarters (division, corps, or army) level, in which first-phase reports were fused with additional

⁷⁷ Ibid., 173.

sources and presented to senior commanders for information and action, which together constituted the exploitation phase of photointerpretation.⁷⁸

The next step, restitution, included detailed updates to photo mosaics and maps of the trench lines to reflect damage done by artillery, new works completed or old ones repaired, and new emplacements or artillery batteries. This step nearly disappeared in the final months of the war, as the battle lines became fluid again, but key aspects remained and became part of what came to be known as second-stage interpretation during the Second World War. An essential element of this process, during both world wars, is what intelligence officers refer to as "change detection." This was the process by which photointerpreters examined each photo in conjunction with previous ones showing the same area or facility (known as "comparative coverage") to determine what the enemy had done there recently. This became enormously important during bombing campaigns in World War II, as photointerpreters and intelligence officers looked for signs of rebuilding at industrial facilities and reconstitution of productive capacity.⁷⁹

By the end of the war, American aircraft had taken well over 18,000 photographs of enemy positions, and photographic sections had made more than 585,000 prints. These increased in number from two in July 1918 to 13 in November as new observation and bombing units arrived.⁸⁰ As photographic officers produced imagery, they sent it to branch intelligence officers, whose job it was to interpret it, use intelligence gained in this process to compile raid reports, and disseminate those reports to senior officers. In fact, all the specific photointelligence products in common use during World War II, including

⁷⁸ Stanley, *World War II Photo Intelligence*, 29.

⁷⁹ *Ibid.*, 26, 29, 32.

⁸⁰ "Final Report of the Chief of Air Service, AEF," in MM, Vol. 1, 17, 22.

photomosaics, target graphics, photo interpretation using stereo viewing, comparative coverage, and strip coverage, were already present well before the end of World War I.⁸¹

Intelligence and photographic officers formed an increasingly close bond in the last year of the war. As partners in the BDA process, they established procedures, especially within flying squadrons, many of which endured through the interwar period and once again evolved rapidly during World War II. However, there was no formal division of labor during World War I, so procedures tended to be *ad hoc* and to vary from squadron to squadron. In some squadrons, intelligence officers interpreted the photographs while the photographic officers focused on maintaining photographic equipment and developing pictures. However, by 1918 more photographic officers were also serving as photointerpreters in bomb squadrons, either in cooperation with the intelligence officers or instead of them. This inconsistency would not resolve itself entirely until 1942, by which time British and American intelligence training schools were producing intelligence officers trained specifically as photointerpreters. Similarly, by World War II, photographic officers focused entirely on the technical and procedural aspects of aerial photography, leaving the interpretation work to their intelligence counterparts.

The British were the first to assign both intelligence and photographic officers to their bomb squadrons and higher headquarters. No. 55 Squadron had them in place by November 1917. The branch intelligence officer was responsible for providing post-raid results and assessments to the 41st Wing staff (the next echelon in the chain of command) by 7:00 a.m. the following morning.⁸² While the photographic officer had cameras and

⁸¹ Stanley, *World War II Photointelligence*, 29.

⁸² Williams, *Biplanes and Bombsights*, 81-82.

photographic plates removed from the aircraft and post-raid photographs developed, the intelligence officer and the group operations officer debriefed returning aircrews, collected their observations, and composed, edited, and signed the squadron's raid reports. These included information from the aircrew debriefing, aerial photographs taken by aircrews during the raid and annotated by the branch intelligence officer, information on enemy air defenses, and on occasion post-strike photographs taken by aircraft from neighboring observation squadrons.⁸³

Ultimately, the Air Ministry Directorate of Air Intelligence (DAI), Section AI1a, received five final copies of each raid report, which stayed in Air Ministry channels for analytical and reference purposes. This directorate was responsible for "compilation of Daily Air Intelligence Summaries" and fused intelligence products compiled using raid reports, prisoner interrogations, agent reports, technical intelligence from downed enemy aircraft, and a variety of other sources. This division of labor between flying squadrons and Air Ministry DAI marked the first point at which BDA data became part of what was called third-phase interpretation and analysis during World War II. Although much more rudimentary and lacking the numbers of sources available in the 1939-45 war, the functions of the Directorate of Air Intelligence indicated increasing sophistication and specialization in the BDA process by the final six months of the war.

There was, however, a significant problem with the way the British organized their BDA efforts. Within the Air Ministry, control of the interlocking functions of intelligence and aerial operations was split between the Directorate of Flying Operations

⁸³ AIR 1/1968/204/273/111, Major H. Paul, "Intelligence Reports of Bombing Raids on German Towns, Aerodromes, etc. Raids before 15th June 1918"; and Major H. Paul, "Further Details," 19 October 1917.

(DFO) and DAI. This division contributed significantly to Air Ministry procedural problems throughout 1918.⁸⁴ Within the Department of Chief of the Air Staff, three staff branches had been established solely to support strategic bombing. One of these, F03 (Strategic Bombing and Independent Force Operations), was located in DFO, while AI1B (Bomb Raids and Targets) and AI1 (Receipt and Distribution of Intelligence) were in DAI. AI1B was responsible not only for targets, but also for records of results of bombing raids. This bureaucratic and illogical split created problems in the targeting and BDA processes for bombing because the offices were physically and organizationally divided, making coordination and agreement on staff issues more difficult.⁸⁵

The American Air Service component of the AEF made a conscious decision to copy British procedure and organizations to the greatest possible degree, an initiative approved by General John J. Pershing, commander-in-chief, AEF, in summer 1917.⁸⁶ Pershing approved the formation of an independent air staff in France, subordinate in name only to Signal Corps Headquarters. From the outset this new intelligence capability involved the collection, interpretation, and dissemination of photointelligence to provide accurate artillery and bomb damage assessments. The report emphasizes the importance of aerial reconnaissance at the corps and army levels and within bombardment squadrons, calling it "the principal new element" in the intelligence equation.⁸⁷

⁸⁴ AIR 1/2087/207/8/37, Secretary, Air Ministry, Air Ministry Office, various memoranda; AIR 1/2087/207/8/37, Air Ministry, List of Staff and Distribution of Duties, October 1918.

⁸⁵ This problem of organizational and physical separation is a serious one and still hampers BDA efforts today. Organizational separation produces a range of bureaucratic and "turf" issues that impede BDA efforts, while physical separation makes close coordination and cooperation more difficult than necessary.

⁸⁶ Historical Division, Department of the Army, Washington D.C., 1948, *The United States Army in the World War 1917-1919*, Reports of the Commander-in-Chief, A.E.F., Staff Sections and Services, Part II (Vol. 13): (Brigadier General D. E. Nolan, G-2, G.S.), 2.

⁸⁷ *Ibid.*, 4.

The American air intelligence organization included Subsection G-2-A-7, Air Intelligence, on General Pershing's staff, and branch intelligence officers, on the British model, at bomb and observation squadrons. The primary duties of G-2-A-7 included interrogation of captured enemy airmen, maintenance of the enemy air order of battle, and acquisition of technical information on enemy air capabilities. Most important for our purposes was the bomb targets department, which was responsible for building target folders, making targeting recommendations to the Directorate of Operations (G-3), compiling records of bombing results, and keeping track of enemy air defense assets. An air activities department provided an ongoing analysis of the effects of Allied air operations, including aerial bombardment. This air intelligence was published in the Daily Summary of Air Information. Although the G-2-A-7 staff had to develop its capabilities from scratch, with extensive assistance from the British and French, it was fully operational by summer 1918, producing BDA materials for use at all echelons.⁸⁸

One of the first things G-2-A-7 did was to identify officers for branch intelligence officer training at the Army Intelligence School and then assign them to bombardment and observation squadrons. These individuals sent a steady stream of BDA reports to G-2-A-7 in the war's closing months. The reports included the number and size of bombs dropped and results as seen by the observer or shown by aerial photographs.⁸⁹ All seven AEF bomb squadrons activated before the end of the war had intelligence and photographic sections.⁹⁰ Branch intelligence officers were responsible for collecting, compiling, and distributing all intelligence relating to bombing operations. Interpretation

⁸⁸ Ibid., 43-44.

⁸⁹ Ibid., 44.

⁹⁰ "Final Report of the Chief of Air Service, AEF," in MM, Vol. 1, 18.

and distribution of aerial photographs took place within hours of a bombing mission. Observers who had taken reconnaissance photos from observation aircraft, or strike photos from bombardment aircraft, assisted the intelligence officer with the interpretation of their imagery. Branch intelligence officers in bomb groups also compiled raid results, produced raid reports, and sent those reports to higher echelons, including G-2-A-7.⁹¹

The "Provisional Manual of Operations of Air Service Units," issued by Brigadier General William "Billy" Mitchell in draft before the St. Mihiel and Meuse-Argonne offensives and in final form on 23 December 1918, gave branch intelligence officers guidance for performing BDA-related duties. For instance, each observation group kept one copy of every photo in the Intelligence Office and two in the Operations Room. "The Intelligence Officer," it continued, "will keep a card index of photographs taken, showing the size of camera used, coordinates of the center, index number of the photograph, altitude and date on which taken, together with a record of the character of the photograph..." It further directed that "a stereoscopic instrument and magnifying glass must be available for the study and interpretation of photographs."⁹²

This guidance hints at two quintessentially Anglo-American qualities that played key roles in BDA developments late in World War I and again in World War II. The first was a penchant for organizing, storing, analyzing, and disseminating intelligence in a systematic manner.⁹³ The second was an affinity for and reliance on technology to

⁹¹ "A Tactical History of the Air Service, AEF," in MM, Vol. 1, 173.

⁹² "Provisional Manual of Operations for Air Service Units," in MM, Vol. 2, 271-272.

⁹³ Third-phase BDA reports were generally produced by the Ministry of Economic Warfare, which focused on the larger economic and military implications of Allied bombing, and by RE8, which provided detailed reports for a series of raids on the same target. Third-phase reports were the end result of deep analysis by BDA experts of all available intelligence pertaining to *overall effects and effectiveness* of Allied bombing, in the case of MEW, or to the accumulated BDA reports available for area bombing of *individual German*

improve organizational effectiveness. The stereoscopic instrument required in Mitchell's directive is a humble example but an immensely important one for the development of photointerpretation and BDA. These instruments allow the user to view photographs in three dimensions where there was a 60° overlap between frames.⁹⁴ The British and Americans figured this out in 1918 and took full advantage of it to reveal secrets hidden in shadows, light, and perspective in aerial photographs.

The chief American photographic officer, who understood the value of stereoscopes, played a major role in their procurement and employment in flying squadrons. Even here, however, there was clear organizational friction in the BDA process. This officer's lessons-learned report emphasized that photographic sections had to take the initiative in getting these tools into the hands of branch intelligence officers. Once officers trained at the Photographic School began arriving at the photographic sections assigned to flying squadrons, they often had "to force the stereographs on the market instead of waiting for the request," an indication that photographic officers often led the photointerpretation process and trained their intelligence counterparts, even though intelligence officers were the designated photointerpreters. The crucial point here is not who introduced the stereoscopes, but the fact that they very quickly became part of the BDA "kit," another sign of the technological and procedural initiative common to American airmen.⁹⁵

Despite BDA-related organizational evolution in the Air Service, there were problems that hampered the effective tasking of intelligence collection platforms as well

cities or American attacks on *specific industrial targets*, in the case of RE-8. Other organizations, such as the Joint Intelligence Sub-Committee, SHAEF G-2, and the Railroad Research Service, also produced third-phase BDA reports. See Chapters 6-8 for details.

⁹⁴ Stanley, *World War II Photo Intelligence*, 179.

⁹⁵ "Lessons Learned, Air Service, AEF," in MM, Vol. 4, 297.

as the reporting and dissemination of BDA-related products. For instance, every branch of the Army had its own photographic sections at unit and headquarters level, all of which received tasking in isolation, which resulted in duplication of effort. The huge number of photographs coming from the unit level also overwhelmed intelligence officers at major headquarters, who were too few in number to begin with and could not keep up with all the first-phase products sent to them from the field. The lack of a centralized photographic interpretation center for bomb damage assessment was a major weakness of WWI organizations that would have to await correction with the British (later Allied) Central Interpretation Unit at RAF Medmenham in World War II.⁹⁶

2.6 Putting BDA Capabilities to Work: The Final Allied Bombing Campaigns

By summer 1918, both the British and Americans had developed air staffs, formal BDA capabilities, and more capable—and numerous—bomber formations. The technological, organizational, and training improvements had combined by the summer of 1918 to create the first true intellectual infrastructure for BDA, even if it was rudimentary. The emergence of intelligence and photographic sections at bombardment and observation squadrons, along with the British Air Ministry Directorate of Air Intelligence and the American G-2-A-7, drove a greater focus on the collection, interpretation, and dissemination of BDA. Although these capabilities appeared late in the war and began to mature only months before the Armistice, they marked the point of departure for BDA developments in World War II, most of which would hinge, directly or indirectly, on these initial advances. With this in mind, we turn to the last and most

⁹⁶ Stanley, *World War II Photo Intelligence*, 32.

ambitious bombing campaigns of the war: the British IF strategic and reprisal campaign, and American-led bombing in the St. Mihiel and Meuse-Argonne offensives.

The British IF bombing campaign in the summer and autumn of 1918 was in essence driven by a contest between the IF's commander, Major-General Trenchard, and the new Chief of the Air Staff, Major General Frederick Sykes. These two men had very different ideas about the potential and therefore the proper employment of bombers. Sykes took his lead from one of his most capable staff officers, Major Lord Tiverton (the Second Earl of Halsbury), a Royal Naval Volunteer Reserve officer who had started his military service in the Royal Naval Air Service (RNAS) and had cross-commissioned to the Royal Air Force upon its establishment in April 1918. He served under Brigadier General P. R. C. Groves, the Director of Flying Operations (DFO) at the Air Ministry. Tiverton impressed on Sykes the vulnerability of Germany's chemical industry to intensive aerial bombardment. In particular, Tiverton believed a concerted attack on Germany's nitrogen-fixation plants would reduce Germany's explosives and propellants production by as much as 80 percent, leaving German leaders no option but surrender as their armies in the field ran out of ammunition. Tiverton's ideas were remarkable not just because they seized, correctly, on the single greatest vulnerability in the German war machine, but also because they represented the first effort to view bombing objectives in terms of target sets that could be attacked and, if damaged sufficiently, bring about a collapse in the enemy's war effort. Tiverton's related initiative to establish realistic bombardment training against white-chalk outlines with the same dimensions as the most important German nitrogen-fixation plants, in which bomber crews would practice navigating to the target in day and night conditions, was yet another of his forward-looking ideas. To

make the training as realistic as possible, Tiverton recommended that antiaircraft artillery firing blanks and searchlights be employed in quantity to create as many distractions as possible, forcing aircrews to stay focused on their bomb runs.⁹⁷

Tiverton reminded his superiors that "The general policy which led to the formation of the Independent Force is the demobilization of the German Armies-in-the-Field, by attacking the root industries which supply them with munitions." Further, he emphasized the paramount importance of concerted attacks on the chemical industry: "The object being to dislocate and finally to obliterate the important key industry which supplies the necessary material for explosives, propellants and poison gas, every effort should be made to concentrate upon this one industry to the exclusion of everything else." In an effort to drive home this last point, he said, "therefore until these targets are completely crippled no others should be attacked."⁹⁸

In a subsequent note Tiverton reemphasized that "The modern Army-in the field is absolutely dependent upon munitions...There are...certain key industries which can be destroyed and the destruction of which will produce a bottle-neck and consequently put an end indirectly to the whole output of munitions." He continued with a reminder that "Some 80% of the whole chemical industry of Germany is concentrated in 12 works within raiding distance from the Nancy [Ochey Airfield] area. The contents are

⁹⁷ For Tiverton's proposals, see AIR 1/460/15/312/101, "Bombing Objectives in Germany, December 1917 – November 1918," November 1917, 1-6. He outlined his ideas for this bombing campaign and the training measures required to make its success more likely. In addition, Tiverton provided target lists for the 15 most important chemical works, 16 key iron and steel furnaces (his second-priority target set), and four engine and magneto works (his third-priority target set, which was designed to deny German aircraft manufacturers critical components to reduce aircraft output). His recommendations were never put into effect due both to the limited numbers and capabilities of available bombers, and to Trenchard's preference to employ his IF bombers in a tactical role.

⁹⁸ AIR 1/460/15/312/101, Lord Tiverton, "Paper on Targets within Easy Reach of Ochey" [IF's home airfield], August 1918, 1.

undoubtedly vulnerable and the works would be practically impossible to duplicate out of reach. The effect, therefore, of destroying these works would be to cut off the supply of high explosives, of mustard gas, and propellant powder. Germany is almost completely relying upon synthetic nitric acid for all high explosives.”⁹⁹

With unique insight and intuition, Tiverton had grasped the greatest underlying weakness in the German war effort: the nitrogen-fixation plants that produced all of Germany’s synthetic nitric acid, an indispensable ingredient in the production of munitions and in fertilizer for German crops, which were already under great stress as a result of the exigencies brought on by the war. He also recognized that nearly all the plants were within range of British bombers based at Ochey, and that they were almost all along the Rhine River, which would make it much easier for bomber crews to locate them. Finally, Tiverton hit upon an absolutely vital fact regarding the major chemical plants on his targets list, a fact that Allied targeting and BDA experts would recognize over two decades later as they studied Germany synthetic oil plants: they were large, vulnerable to bombing, and not capable of dispersing their operations or moving wholesale to another location out of range of British bombers.

The only thing Tiverton did not address directly was the BDA process to be employed in determining the effects and effectiveness of a bombing campaign against the German chemical industry. In the voluminous staff papers he produced during the Great War, not one specifically addressed question of BDA. Nonetheless, there is overwhelming evidence throughout his writings that Tiverton had considered BDA implicitly in the aerial bombardment plans he developed. His preoccupation with the

⁹⁹ AIR 1/460/15/312/101, Lord Tiverton, “Notes on Targets,” May 1918, 1.

bomb weight required to destroy a given target or all of those within a larger target set, for instance, indicate that Tiverton understood a concerted bombing effort would be required, and, by extension, a means for determining its effects and effectiveness. However, he never discussed BDA explicitly, and we may take this as an indication that, despite all the efforts made during the 1914-18 war to establish an intellectual infrastructure for it, BDA had not yet become an integral part of the targeting-operations-assessment feedback loop as it would during World War II.

Sykes, who read Tiverton's staff papers and concurred with their recommendations, pushed Trenchard to attack the German chemical industry—and in particular nitrogen-fixation plants—in an effort to undermine the enemy's war industry. In theory, this was to be the IF's focus. In reality, Trenchard ignored Sykes and focused on attacking tactical targets in support of ground forces. His preferences here included railroads and marshalling yards to slow the German advance during the Michael offensives, and airdromes to destroy German fighters or keep them occupied in air defense duties. It is clear that Trenchard followed Generalissimo Ferdinand Foch's and Field Marshal Haig's guidance that airpower must support ground forces.¹⁰⁰ Even worse, from the Air Staff perspective, was Trenchard's infuriating habit of sending out press releases with details of raid results after every IF mission, most of which focused not on strategic or reprisal targets, as directed by the Air Ministry, but on tactical targets.¹⁰¹ Brigadier General Percy Groves, Chief of the Directorate of Flying Operations, highlighted in a memo to

¹⁰⁰ Williams, *Biplanes and Bombsights*, 167-170, 179-180. The idea that bombing should support ground forces is by no means a bad one. In fact, the transportation and oil campaigns during World War II were designed specifically to assist Allied ground forces. The problem in Trenchard's case was his refusal even to consider, much less put into practice, Tiverton's plan for an attack on German nitrogen-fixation plants.

¹⁰¹ *Ibid.*, 162-163.

Sykes the degree to which Trenchard was diverging from the IF's stated employment policy, which was to carry out concerted attacks against German industry. From 1 June to 31 August, IF attacks on the chemical industry declined from 14 percent to 9.5 percent, while attacks on enemy airfields rose from 13.3 percent to 49.5 percent. Groves also noted that raids on marshalling yards, which made up most of the other missions, were "far too high" given the stated bombing directive. None of this haranguing did any good. Trenchard continued along the lines he had already established.¹⁰²

By September 1918, Trenchard commanded 9 bombing squadrons totaling 110 aircraft with an aggregate bomb load of 142,000 pounds.¹⁰³ This was a significant figure, but it paled when we consider that the British planned to field 60 squadrons of Handley-Page V/1500 bombers (840 aircraft) in 1919, each of which carried 7,500 pounds of bombs, for an aggregate bomb load of 6,300,000 pounds, or over *44 times* what Trenchard's bombers carried—a huge increase in capability that would have driven forward decisively the practice of bombing and BDA.¹⁰⁴

Despite the tactical focus of the bombing campaign and Trenchard's view that bombing in any guise was bound to be ineffective given the technological, navigational,

¹⁰² AIR 1/460/15/312/101, Groves to Sykes, "I.F., R.A.F. 'Policy,'" 11 September 1918.

¹⁰³ Ibid., 189; Raleigh and Jones, *The War in the Air*, Vol. 6, Appendix XV.

¹⁰⁴ See AIR 1/2104/207/36, Air Ministry A.I. 1, "Results of Air Raids on Germany," 3rd ed., January 1920, Appendix VII, "Chart Showing Number of Squadrons and Type of Machines available per month." Trenchard had nine squadrons under his command once the IF reached its peak strength in the summer of 1918. These included three squadrons of DH-9s and one of DH-4s, which could carry 460 lbs. of bombs. Trenchard also had five squadrons of Handley Page bombers, including two of O/400 day bombers, which carried 2,000 lbs. of bombs, and three of Handley Page O/100 night bombers, which also carried 2,000 lbs. of bombs. In addition, he had one squadron of Sopwith Camel fighters as dedicated escorts for his bombers. The British strategic bombing plan for 1919 included 60 squadrons of Handley Page V/1500 bombers (roughly 840 aircraft), which would have carried out a truly strategic air campaign. Of course, this did not come to pass, but had the war continued both strategic bombing and BDA practice would have made huge strides. See *Air Power: A Modern Illustrated History* (New York: Exeter Books, 1979), 215, 221, 223, 231, and 245 for bomb loads and other information on these bombers.

and other limitations at the time, British air intelligence and photographic officers produced a steady stream of BDA reports ("raid reports") for each target struck. Most of these reports included inputs from aircrew debriefings and photographs taken by the one or two bombers in each raid that carried cameras, or by dedicated reconnaissance aircraft, which had by this time begun to collect photographic cover for the more important bombing missions. Nonetheless, the postwar British and American bombing surveys demonstrate a persistent tendency to overestimate the damage done to enemy targets, particularly with respect to industrial facilities and airdromes, the former because bomb damage was difficult to gauge, and the latter because results generally looked more impressive than they really were because hangars and runways were easy to repair.¹⁰⁵

The same kinds of BDA problems occurred during the St. Mihiel and Meuse-Argonne offensives, during which General Mitchell exercised centralized control of 323 Allied bombers, including 5 American bomb squadrons and a French night bombardment group. In addition, British IF squadrons were under Mitchell's operational control. This force, while small by World War II standards, was an unprecedented concentration of bomber strength. For the St. Mihiel offensive, bombers were tasked "to destroy and harass the rear areas of the battlefield, and to attack military and industrial objectives beyond the range of artillery" and "to cause a dispersion of enemy anti-aircraft defense (anti-aircraft guns, pursuit patrols, etc.)"¹⁰⁶

¹⁰⁵ AIR 1/2104/207/36, Air Ministry A.I. 1, "Results of Air Raids on Germany," 3rd ed., January 1920, notes that "Photographs taken during, or on the day following, an air raid often provide exact evidence of our bomb-dropping. For the tendency to overestimate damage to German airfields, see AIR 1/1998/204/273/263, Major H. Paul to Air Ministry, "Report of Allied Bombing Raids on Germany: Aerodromes and their Results," 26 February 1919.

¹⁰⁶ "Final Report of the Chief of Air Service, AEF, in MM, Vol. 1, 37-39; HQ Chief of Air Service, 1st Army, Circular No. 1, "Day Bombardment," 19 August 1918, in MM, Vol. 3, 44.

Bombing did some damage to German railroads, marshalling yards, and airdromes, but BDA was often sketchy and overestimated damage. Attacks on high-value targets, including the marshalling yard at Conflans, were often effective in slowing the movement of German troops and supplies to or from the front lines. Major George E. A. Reinburg, Commander, 2nd Day Bombardment Group, summed up the results of these attacks:

Resulting from the bombing of principal enemy railroad centers, the traffic at those centers was so tied up, that trains had to be rerouted thru other channels, causing considerable inconvenience and delay. The morale of the railroad workers was considerably lowered, judging from the testimony received after the armistice. As a result of the bombing of enemy concentration several enemy counterattacks were said to have been checked at the outset. During enemy retreat the bombers caused considerable confusion along the route. Aside from these considerations the material damage done by bombers during their raids was considerable and has not been calculated. The indirect results affecting the morale of the enemy and our own troops can scarcely be estimated, but helped considerably towards a successful conclusion of hostilities.¹⁰⁷

This after-action report, based on numerous raid reports completed during the course of the battles, contains assessments based on hard evidence such as aerial photographs, soft evidence such as aircrew reports, and even softer evidence such as railroad workers' comments after the Armistice about the morale effects of Allied bombing.

Also noteworthy is Reinburg's comment that "material damage done by the bombers during their raids was considerable and has not been calculated." Clearly, shortcomings still existed in the BDA process. A mature BDA infrastructure would have been able to calculate physical damage with a relatively high degree of accuracy and provide insights on the effects and effectiveness of bombing. The limitations of aerial photography, *at the time*, as a means for calculating physical effects were clearly at the center of Reinburg's

¹⁰⁷ "Lessons Learned, Major George Reinburg, C.O. 2nd Day Bombardment Group," in MM, Vol. 4, 91.

concerns. His comments about the morale effects of bombing also remind us that the Americans, too, were under the sway of Trenchard's pronouncements.

The tendency to overestimate the effects and effectiveness of bombing, combined with the frustrations of a BDA infrastructure not yet mature, led several American airmen to vent their frustrations in post-Armistice reports. Ironically, Major Reinburg, having conjectured about the morale effects of American bombing, then complained that

While it was necessary at all times to maintain a certain amount of secrecy concerning the operations of the bombardment squadrons, yet a more complete summary of intelligence concerning the damage done on the various raids could have helped out wonderfully. It was found out afterwards that some of the raids which were listed as unsuccessful were successful in wiping out a part of a machine gun training school for German officers.¹⁰⁸

The deeper issue is clear: American senior officers, including bomb squadron commanders, felt they were getting too little BDA, and getting it too late, to make concrete determinations about bombing's effects on the enemy. Instead, they had to rely on the same unverifiable platitudes Trenchard employed: the morale effects of bombing, its role in drawing German air defense assets away from the front, and the supposedly disproportionate effects of bombing on the enemy given the limited resources committed to it. As recent scholarly works have noted, these claims were wildly overblown. Unfortunately, the rudimentary state of BDA at the time did nothing to dispel any of these myths and in fact may have contributed to them simply by a lack of detail.

The first major test of the nascent American BDA capability exposed other weaknesses as well. First Lieutenant Alfred T. Bellinger, who served as G-2-A-7, noted that despite the wise decision to assign branch intelligence officers to all bombing and

¹⁰⁸ Ibid.

observation units, individuals selected were of uneven quality. (Translation: air intelligence officers were generally not chosen from among the finest the Army had to offer.) Most, he lamented, lacked breadth of experience, and many were "ignorant or tactless," a definite problem for officers who were supposed to work with aircrews to get the best possible intelligence from debriefings. Bellinger also decried the fact that G-2-A-7 was itself an "amorphous office" with neither the manpower nor the cohesiveness to oversee a major BDA effort.¹⁰⁹ Of course, the fact that a first lieutenant was in charge of the entire air intelligence effort says something about the relative importance of bombing and BDA in the greater scheme of American military operations. These problems persisted during the interwar period and into the early years of World War II.

First Lieutenant Robert B. Rhoads, assigned to the Operations Section, Second Army Air Force, raised another organizational shortcoming affecting the BDA process during the war's final battles: The G-2 (Director of Intelligence), GHQ, AEF had tasking authority for all photographic and visual reconnaissance missions. As Rhoades noted:

In the first place, missions which are given are often prepared by officers totally unqualified to judge of the possibilities and limitations of the Air Service, and often orders for wholly impossible missions go to the Group Commanders without the knowledge of the Army Air Service Commander, who might have been quite able, having seen the assignments, to so alter and rearrange them that they could have come within the scope of possibility... Then, too, the system whereby G-2 assigns missions direct, robs the Army Air Service Commander of the benefit and value to the service, of his experience, whereas by a wise selection, missions could undoubtedly be accomplished much more efficiently in every respect.¹¹⁰

These concerns highlight the problems relating to that tasking and execution of reconnaissance missions for BDA or any other purpose. The fact that G-2 had tasking

¹⁰⁹ "Lessons Learned, 1st Lt. Alfred T. Bellinger, G-2, A-7, GHQ, AEF," in MM, Vol. 4, 216-217.

¹¹⁰ "Lessons Learned, 1st Lt. Robert B. Rhoads, Operations Section, Second Army Air Service," in MM, Vol. 4, 218.

authority meant an individual with little or no awareness of the tactical and operational situations, and who was himself not an "operator," had control of *all* American reconnaissance assets. This led to a wide array of problems including an inevitable effort by commanders at the army, corps, and division levels to subvert the process and task reconnaissance assets "on the side," which they did with much success. Consequently, by the end of the war, there was not even a hint of centralized tasking and execution of reconnaissance assets, which meant BDA suffered, along with all the other activities dependent on aerial reconnaissance. The good news for American BDA efforts in World War II was that tasking authority was no longer vested in the G-2 after the Armistice. In fact, the centralized tasking and execution of reconnaissance sorties would become very effective and contribute to the superb BDA capabilities developed in that later conflict.

The after-action report from the Photographic Section, GHQ, AEF, was also instructive with respect to BDA-related shortcomings. Most important was the statement that "photography was certainly not used as fully or as intelligently as it could have been."¹¹¹ Among the reasons for this, according to the Photographic Section, were a lack of knowledge in Army as to value of photography and its uses, a shortage of trained personnel for the interpretation and exploitation of photographs (a not-so-veiled criticism of branch intelligence officers), and an unclear and inefficient division of responsibility for photography between the photographic and intelligence sections at the unit, headquarters, and GHQ air staff levels. The report asserted that

The Intelligence Section was not only charged with the interpretation of photographs, but also with ordering them to be made. With the exception of one or two cases the Branch Intelligence Officers know absolutely nothing about

¹¹¹ "Lessons Learned, Photographic Section, Air Service, AEF," in MM, Vol. 4, 292.

photography or its possibilities and consequently were not able to judge as to what could be done or what was desirable. It is believed that the Photographic Interpreter should have a very thorough knowledge of photography. Frequent cases have been noted where an interpreter [in other words, branch intelligence officers] who knew nothing about photography mistook imperfections in the photographic plate or print for things recorded by the camera.¹¹²

The report continued its scathing attack on the intelligence role in producing imagery with a reminder that mass photographic printing for the St. Mihiel offensive, which was performed by intelligence sections, was far behind schedule, while photographic sections, which took over this process during the Meuse-Argonne offensive, did much better.

The report concluded with several recommendations, including the idea that photographic officers, rather than intelligence officers, interpret aerial imagery:

With aerial photography clearly understood and an organization adequate to exploit same, this Photographic Officer becomes a very important figure in the Air Service...With the aid of the observers and the Photo Section he will interpret the photographs and properly record them. From this point onward the photographic material properly belongs within the domain of the Intelligence Section, so that this Photographic Officer in reality acts as a liaison between the Air Service and the Intelligence Section. This Photographic Officer should not command or administer the Photo Section proper, but simply direct this work. The administration and laboratory work should be entrusted to a subordinate officer. This Photographic Officer should be responsible for the photographs but not the photography. He should be in a position to know what is wanted and what can be accomplished.¹¹³

After the war, the Air Service (later Air Corps) adopted most of these recommendations. Unfortunately, they did so mostly for aerial mapping rather than photointerpretation, two distinct missions requiring very different skills. The latter, which was crucial to the BDA process, disappeared almost entirely. Perhaps the best that can be said is that BDA during World War II was organized almost exactly in line with these recommendations, with one key exception: the photointerpreters and the photointelligence process in the

¹¹² Ibid., 293-294.

¹¹³ Ibid., 295-296.

RAF and USAAF would be dominated by intelligence officers, not photographic officers, who directed only the processes and equipment required to take and develop photos.

Despite these problems, there were bright spots in the BDA process. Captain Heber Blankenhorn, Chief, Propaganda Section, G-2, GHQ, AEF, noted the success of the American leaflet program in the war's closing months. The Propaganda Section prepared and printed 5,164,750 copies of 18 distinct leaflets of which over 3,000,000 copies were dropped over German lines. Blankenhorn described the airplane as "the great weapon of propaganda in the AEF, nine to twelve Aviation Fields handling the leaflets, averaging in distribution 5,000 to 10,000 leaflets a day and some as high as 30,000 a day."¹¹⁴ He also provided good evidence of his leaflets' success, including prisoners coming over in increasing numbers with the leaflets in their pockets or held out in their hands; captured German orders and other efforts to counteract the effects of the leaflets, and increasingly shrill exhortations, including one from Hindenburg, to ignore the leaflets; and post-Armistice letters from German officers noting the role of the leaflets in lowering morale. Given that the effort began in May 1918, as the Germans were advancing, and began to draw German deserters to the Allied lines almost immediately, it appears as though the effects and the effectiveness of the propaganda effort were both rapid and substantial. Blankenhorn closed by saying: "use of the Air Service for propaganda purposes in any future war against a nation whose soldiers are capable of reading should undoubtedly be a part of the recommendations of the War Plans Division of the General Staff."¹¹⁵

¹¹⁴ "Lessons Learned, Capt. Heber Blankenhorn, Chief, Propaganda Section, G-2, GHQ, AEF," in MM, Vol. 4, 229.

¹¹⁵ Ibid., 221-230.

The results of the propaganda campaign, and the means employed to assess its effectiveness, are important. Although propaganda leaflets had little effect in the Second World War, they have reemerged in recent years with great effectiveness, particularly in the two wars with Iraq. Blankenhorn's emphasis on dropping leaflets *specifically when the enemy's morale was already low* was crucial. The nontraditional sources involved in the BDA process for this propaganda effort, including prisoner-of-war reports, captured statements from enemy leaders, and captured letters to and from soldiers at the front, remind us that there are different kinds of air campaigns, or at least different facets within them, all of which may require different kinds of BDA.

2.7 Conclusions: BDA at the End of the Great War

The practice that came to be known as "damage assessment" during the First World War had its origins in a need to know the accuracy, effects, and effectiveness of aerial bombardment. Although the BDA process as it evolved in the Great War had its genesis in artillery damage assessment, it gradually became a distinct field of endeavor as air staffs with dedicated air intelligence sections emerged in both the British and the American air arms in late 1917 and early 1918. The fundamental differences between artillery and aerial bombardment were the much greater range of the latter, but also its much poorer accuracy given the rudimentary state of navigation instruments, bombs, bomb release mechanisms, and bombsights. This meant that, even as bombsights and other bombing technologies evolved, the emerging cadre of BDA experts in the British and American air arms had to find ways to determine the accuracy, effects, and effectiveness of bombing. Their efforts in this arena were varied and included installation of cameras in bomber aircraft for the purposes of collecting strike

photographs, the use of “stereo pairs” and stereoscopes during the last year of the war, a gradually increasing ability to pry observation aircraft away from ground commanders and employ them, if only occasionally, as post-strike BDA collectors, and dedicated training courses for photointerpreters.

The results of the final British and American air offensives during the First World War, as they related to the development of BDA, were fourfold. First, they reemphasized how rudimentary BDA capabilities still were, despite the emergence of a fledgling intellectual infrastructure. Second, in spite of its rudimentary nature, the very fact that an intellectual infrastructure with real substance emerged during the war, and one that was able to provide effective BDA reports at least some of the time, was highly significant and would have an indirect but nonetheless substantial impact on the creation of its more sophisticated and capable successor during the Second World War. Several key officers with air intelligence and BDA experience from the first war would reemerge during the second to rebuild key elements of the intellectual infrastructure by leveraging the much more advanced technologies and far more sophisticated air intelligence organizations emerging in the late 1930s and early 1940s. Third, air intelligence officers’ more than occasional inability to collect sufficient intelligence about the *physical effects* of bombing prompted them and some operational commanders, including Trenchard, to make unsubstantiated and often outlandish assertions about the *morale effects* of bombing. Fourth, as will become evident in the following chapter, British and American postwar bombing surveys and other reports that assessed the effectiveness of Allied air action were different in character and arrived at divergent conclusions about the most efficacious employment of bombers. It is to these postwar surveys that we now turn.

CHAPTER 3

LESSONS LEARNED, UNLEARNED, AND FORGOTTEN: ANALYSES OF AERIAL BOMBARDMENT IN WORLD WAR I AND THEIR CONSEQUENCES

As noted at the end of the previous chapter, the British and American postwar bombing surveys and other reports assessing the effectiveness of the war's bombing offensives, including the combined British-French effort spearheaded by No. 3 Wing RNAS, IF operations in the summer and fall of 1918, and the American bombing efforts in support of the St. Mihiel and Meuse-Argonne offensives, were fundamentally different in character. The report produced by the RAF Air Ministry was a self-serving political document that enshrined morale bombing. The American reports, including the Air Service lessons learned and the postwar bombing survey, were more practical in their focus, seeking to determine how best to employ the air weapon—and by extension BDA—in the next war. These reports, collected into a comprehensive Air Service document and therefore available to American airmen during the interwar period, had a significant cumulative impact on the development of theory, doctrine, and capabilities.¹ The bombing survey had a particularly major impact in this regard because a summary version made it to the Air Corps Tactical School (ACTS), HQ Air Service, and several other locations. The ACTS strategic bombing advocates relied on it as a foundational document in developing precision, daylight bombardment doctrine. The implications for

¹ This is the series of reports contained in MM, Vol. 4.

BDA during World War II were implicit but nonetheless dramatic. A closer look at the impact of these postwar reports, and their key wartime proponents, is necessary to develop an understanding of the close relationship between bombing doctrine and BDA development during and after World War I.

First, however, we must assess the influence of three key players in the BDA-development process during and after World War I. The first two, Major Lord Tiverton, and Major-General Trenchard, both of whom we met briefly in the previous chapter, had very different ideas about the efficacy and optimum employment of aerial bombardment, ideas that had a major influence on the development of British and American BDA capabilities before and during the Second World War. The third individual, Lt Col Edgar S. Gorrell, an American air officer, was heavily influenced by Lord Tiverton's ideas about bombing and BDA. His writings during and after World War I had a profound influence on the development of American strategic bombardment doctrine and by extension the BDA capabilities required to support such an effort.

3.1 The Tiverton-Trenchard Debate and Its Effects on BDA

The development of British BDA capabilities in the final year of the war and throughout the interwar period was affected profoundly by an acrimonious debate between two British officers introduced in the previous chapter. The first, Major Lord Tiverton, advocated a bombing plan for attacking "bottleneck targets" within Germany's munitions industry, particularly nitrogen-fixation plants. The second was Major-General Sir Hugh Trenchard, who commanded the Independent Force (IF), which was in effect the RAF's heavy bombardment force, from its inception in June 1918 until the end of the war, and then became RAF Chief of Air Staff in the immediate postwar period. These

two men had profound disagreements about how best to conduct an air campaign against Germany in particular and industrialized countries in general. Although neither man appears to have looked directly at the role of BDA in a strategic bombing campaign, Tiverton's theories acknowledged implicitly the crucial importance of *detailed* BDA in determining bombing's effects and effectiveness against specific targets, while Trenchard's focus on morale bombing assumed that *detailed* BDA would be superfluous.

Tiverton's staff work was remarkable not only for its clear grasp of industrialized warfare and the potential vulnerabilities of an enemy's war industry, but also for the influence it would exert many years later on American bombing doctrine and, indirectly, on the development of sophisticated BDA capabilities in Both Britain and the United States between 1937 and 1945. In 1917, Tiverton came to view the enemy's war industry as a collection of target sets or "systems" based on functional specialization, the first theoretician of aerial warfare to do so. He said that the first question to consider in a strategic bombing campaign against German industry was that of the overriding objective, which in this case was to cripple the German war effort by attacking key industrial targets. Tiverton identified vulnerable German industries and, within them, "bottleneck targets," individual sites which, if destroyed, would cause the German war effort to collapse. Of these, he placed the German chemical industry, in particular nitrogen-fixation plants, at the top of his prioritized target lists. He also produced a number of papers emphasizing the importance of concentration, logistics, navigation, and proper armaments for an effective bombing campaign against Germany.²

² See these documents, all by Lord Tiverton, in AIR 1/460/15/312/101: "Bombing Objectives in Germany, December 1917 – November 1918," November 1918; "Paper on Targets within Easy Range of Ochey [IF's

Tiverton was also convinced that to identify the most lucrative targets, the Air Ministry should consult with engineers, industrialists, and technicians for insights into the vulnerabilities of German industries. This recommendation prefigured the emergence during World War II of the Ministry of Economic Warfare and, on the American side, the Committee of Operations Analysts and the Enemy Objectives Unit, which gathered detailed information on German industry and made it available to targeteers and BDA experts. Tiverton's proposals confirm that he understood the feedback loop that exists between targeting, bombing, and damage assessment.³

Finally, Tiverton advocated a shift from amorphous target lists and morale bombing—in opposition to Trenchard's approach—to a systematic choice of targets according to their effect on key industries, and the use of specific bomb types and bomb sights depending on the specific target in question. However, nothing came of this or Tiverton's other efforts to push IF bombing from a morale to a target-system focus.⁴

primary airbase], 31 August 1918; and "Notes on Targets," May 1918; also, see Jones, *The Origins of Strategic Bombing*, 142-147.

³ See AIR 1/460/15/312/101, Minute, Tiverton to Groves, 15 June 1918, in which he described his meeting with a Mr. Jacobs, Managing Director of the Tudor Accumulator Works before the war. Mr. Jacobs noted that all the accumulator plates for recharging U-boat batteries were made at a single large plant at Hagen, in western Germany, and a smaller plant in Berlin. He further noted that the building where the formation process occurred was the most vital one in the entire plant, the destruction of which would put the works out of action. Tiverton held a similar meeting with a Mr. Skelton, one of Great Britain's prominent steel manufacturers. See AIR 1/460/15/312/101, Minute, Tiverton to Groves, 18 June 1918. Mr. Skelton provided detailed information on the Bessemer and Siemens processes for producing steel, including visual cues that aircrews could use to locate and bomb the targets successfully. It is also significant to note that Tiverton's meeting with Mr. Skelton occurred during a larger meeting of the War Trade Intelligence Department, which was charged with discovering German economic weaknesses and exploiting them to the fullest possible extent. This organization provided Tiverton with much of the information he needed to build his target lists for chemical (nitrogen-fixation) plants, steel plants, and aircraft engine and magneto works, which in his view comprised the three most vital and vulnerable German "bottleneck" industries. See AIR 1/460/15/312/101, War Trade Intelligence Department to Tiverton, 10 July 1918, which contained information on Chemische Fabrik Rhenania, one of the more important German chemical plants.

⁴ Tiverton's frustration was evident in AIR 1/460/15/312/101, "The Possibilities on Long Distance Bombing from the Present Date until September 1919," 1 October 1918, 1. In this memo to Groves and Sykes, Tiverton reminded his bosses that the original purpose for which the IF had been formed was to destroy German nitrogen-fixation plants and thus render the German Army "de-munitionised." He then

Trenchard rejected Tiverton's recommendations; indeed, it is doubtful that he even seriously considered them. As General Officer Commanding of the IF, he exercised operational control *independent* of the Air Ministry and Major General Sykes, the RAF Chief of Air Staff. This allowed Trenchard to run the bombing campaign as he saw fit. Trenchard's superiors could cajole or confront him on these issues but lacked the authority to order changes in the campaign.

What, then, was Tiverton's long-term influence? As will become clear later, it was tremendous with respect to American bombing doctrine and BDA development, on the one hand, and British BDA development on the other. Tiverton's pioneering use of mathematical reasoning to produce answers to such problems as the probable number and weight of bombs that would be required to destroy a particular type of factory from a specified height also anticipated by two decades the methodology later known as operational research, although his papers were filed away and a new generation of officers in effect had to "rediscover" this science by trial and error in the 1930s.⁵

Perhaps the greatest irony is the fact that Trenchard, called the "Father of the Royal Air Force," had no enthusiasm for strategic bombing under any circumstances until long after Armistice Day. Trenchard ignored Air Staff directives to give priority to German

noted that Trenchard had made only one attack on a major German chemical plant, the Badische Anilin und Soda Fabrik at Ludwigshafen, and that he had made only a few other attacks on German industrial plants, none of them high-priority targets.

⁵ For Tiverton's role as the unacknowledged father of operational research, see Neville Jones, *The Beginnings of Strategic Air Power: A History of the British Bomber Force, 1923-1939* (London: Frank Cass, 1987), xiii. Ironically, Tiverton, who was in many ways the father of RAF operational research, was not even mentioned in the Air Ministry's official history, entitled *Operational Research in the RAF* (London: Her Majesty's Stationery Office, 1963). This more than anything demonstrates the degree to which his inspired work fell into obscurity in Great Britain. However, as will become clear in this chapter, his work was anything but obscure in the US Army Air Corps and its Air Corps Tactical School (ACTS) between the wars, where his theories formed the basis for the development of high-altitude, precision, daylight bombardment of German "bottleneck" target sets.

industrial targets and instead employed IF bombers against tactical targets, mostly airdromes, railroads, and marshalling yards. He also preferred to attack cities rather than specific industrial targets, arguing that such an approach would have the maximum *morale effect* on the German people. As one scholar notes,

Trenchard made this concept of air warfare the basis of his policy in the years following the war, and this led the peacetime air staffs to believe that the dropping of large tonnages on urban areas would present few difficulties. This in turn bred a complacency among the planners, and caused them to underestimate the problems concerned with finding the way to the target area and dropping bombs accurately on a specific objective.⁶

This is a telling insight since Trenchard's approach to bombing, which assumed that *every bomb* dropped had a morale effect on German civilians regardless of where it fell, was therefore automatically *effective* in lowering German morale, with the consequent assumption that each bomb dropped on Germany would bring the Germans a few steps closer to the negotiating table. Ironically, Trenchard and his staff relied on a definition of morale bombing developed by Tiverton in one of his staff papers, which characterized it as anything "which hinders the German output of munitions, apart from actual material damage done to works."⁷ Trenchard's view that bombs would have the maximum morale effect regardless of where they fell took Tiverton's definition to an illogical extreme and made BDA a *functional* irrelevancy by advancing a tautology instead of a logical approach for determining bombing's effects and effectiveness.

Trenchard nonetheless required submission of detailed raid reports immediately after each mission and insisted on reviewing them personally. Once the original copy of a

⁶ Ibid., 18-20.

⁷ AIR 1/460/15/312/101, Lord Tiverton, "The Possibilities on Long Distance Bombing from the Present Date until September 1919," 1 October 1918, 2.

report arrived from the field, Trenchard's staff dutifully retyped it and provided a copy to Trenchard, who often appended comments, most of which emphasized the morale effect on German civilians. In this sense, BDA reports were important *political* documents for Trenchard, who was determined to show the Air Ministry and the War Department that every bomb dropped on German territory degraded German morale. Trenchard argued tirelessly that morale effects were great even when physical damage was minor.⁸ Among his most notable claims during the IF air offensive was the statement that "it would be no exaggeration to say that every unit of the Independent Force immobilizes at least 50 times its fighting value from the ranks of the enemy." When combined with his immediate postwar assertion that "at present the morale effect of bombing stands undoubtedly to the material effect in a proportion of 20 to 1, and therefore it is necessary to create the greatest morale effect possible," it becomes clear that Trenchard was fixated on the morale rather than the physical effects of bombing. His claims, made without any serious reflection, proved hollow in succeeding decades and received their death knell in 1944, after the RAF's area bombing campaign failed to break German civilian morale.⁹

It is important to note that Trenchard saw little potential in *any* kind of strategic bombing campaign in 1918 given the rudimentary technologies, navigational training, and munitions involved, and the small number of bombers assigned to the IF—only nine squadrons (about 110 aircraft) in September 1918, at the height of IF bombing operations, including four comprised of single-engine DH-4s and DH-9s, two of the heavier, twin-engine Handley Page O/400 day bomber, and three of the Handley Page

⁸ Williams, *Biplanes and Bombsights*, 48-53.

⁹ AIR 6/19, Dispatch, Major General Hugh M. Trenchard, Dec. 12, 1918; Dispatch, 1 Jan 1919, reprinted in *Aeroplane*, 8 January 1919, 129-131.

0/100 night bomber).¹⁰ Consequently, he apparently decided even before he took command of the IF that, given the impossibility of doing serious material damage, his focus would have to be on morale bombing, which was advantageous if only because it was impossible to quantify the morale effects of bombing—and therefore to disprove Trenchard's assertions that bombing's morale effects were out of all proportion to any physical damage it might cause. Trenchard's focus also stayed on aerodromes and railways, rather than on industrial targets, in keeping with Haig's preference that bombers provide direct support the ground war. Bombing statistics reveal these facts: aerodromes and railways together received 68.3 percent of total sorties in June 1918. The totals were 74 percent in July, 80 percent in August, and 83.3 percent in September.¹¹ Many of these sorties supported British and Allied ground forces, first in their retreats during the Michael Offensives, and then during their advance in the St. Mihiel and Meuse-Argonne offensives, another sign of the ground war's primacy.

Perhaps most revealing here, despite Trenchard's *public* assertions that the morale effect of bombing had been "great—very great," is his *private* diary entry on the day of the Armistice: "Thus the Independent Force comes to an end. A more gigantic waste of effort and personnel there has never been in any war."¹² Unfortunately, Trenchard's public statements about the morale effects of bombing had major ramifications for the development of BDA capabilities in the interwar period.

¹⁰ Williams, *Biplanes and Bombsights*, 189-190. Williams notes the irony of the IF's "upgrade" from DH-4 to DH-9 bombers given the latter's inferior airspeed and combat ceiling, and maintenance-intensive engine.

¹¹ Williams, *Biplanes and Bombsights*, 177-179, 229; Malcolm Cooper, *The Birth of Independent Air Power: British Air Policy in the First World War* (London: Allen and Unwin, 1986), 131-136.

¹² Private diary, 11 November 1918, Trenchard Papers, MFC 76/1/32, quoted in Malcolm Cooper, *The Birth of Independent Air Power*, 136.

Despite the fact that Trenchard's views on bombing prevailed, Tiverton exerted a tremendous influence on American strategic bombing advocates during World War I and the interwar period. His advocacy of precision bombing by definition required an equal emphasis on BDA as the means of determining the effects and effectiveness of aerial bombardment, a fact not lost on American airmen in the interwar period and during World War II. Ironically, Tiverton had far more influence on American bombing and BDA theory, doctrine, and practice than he ever had on the British. The one exception, as we will see in the following chapter, was the British effort, between 1937 and 1940, to develop a detailed set of target materials in case of war with Germany. The resulting organizational and intellectual advances, including the Ministry of Economic Warfare and the RAF's operational research capability, had their genesis in Tiverton's efforts. Nonetheless, the British, who developed an unparalleled BDA capability early in the Second World War largely as an extension of thinking pioneered by Tiverton, and who had intended originally to attack German war industries in precision, daylight attacks, ultimately made a conscious choice after the failure of their early daylight bombing efforts to pursue a night, city-bombing strategy. Consequently, as will become clear in succeeding chapters, the superb British BDA capabilities in place by 1943 ended up providing greater support to the *American* daylight bombing effort and were in fact tailor-made for it in many ways. This is not to say that British BDA capabilities did not provide insights on the effects and effectiveness RAF Bomber Command's city-bombing offensive—they provided a great deal of information—but rather that British "precision" BDA and American daylight "precision" bombardment were an ideal match. Tivertonian ideas about precision daylight bombardment of crucial target sets, with all they implied

for the development and practice of BDA, exerted their greatest influence during American operations in support of the Combined Bomber Offensive.

3.2 The Tiverton-Gorrell Connection and American BDA Development

Major (later Lieutenant Colonel) Edgar S. Gorrell became head of the Strategical Section, Zone of Advance, American Expeditionary Forces, in September 1917. While serving in this capacity in Paris, he developed a close professional relationship with Lord Tiverton, whose writings on strategic bombardment he read avidly. In fact, it is now clear that the "Gorrell Plan" for the strategic bombing of Germany, long attributed to the American, was in fact a copy of Tiverton's draft strategic bombing plan combined with Trenchard's ideas about morale effects and his own views that bombing should be a day-and-night, around-the-clock effort to destroy key German target sets and especially the "bottleneck targets" within those target sets. A letter from Gorrell to Tiverton thanking him for the loan of his original notes on strategic bombing, is particularly revealing in this regard, as is a review of the two men's bombing plans, which are nearly identical.¹³ Gorrell's plan was a synthesis of Tiverton's emphasis on analytical planning and systematic implementation, Trenchard's ideas about morale effects, and his own views that bombing could be decisive by depriving the German Army of certain key items by destroying certain types of industry, thus breaking the trench stalemate. The "Gorrell Plan" became a foundational planning and educational document at the Air Corps Tactical School and in this sense represents one of the first glimmers of the industrial

¹³ Tiverton, 10 December 1917 and 5 January 1918, both in Halsbury Papers, AC 73/2, box 2, RAF Museum, Hendon.

web theory and AWPD-1.¹⁴ Nonetheless, senior US Army commanders curbed this move towards strategic bombing, for very sound reasons at the time, and the Air Service instead engaged entirely in tactical bombing in direct support of the St. Mihiel and Meuse-Argonne offensives.

However, it is the fact that Gorrell's—read Tiverton's—plan had such a great influence on American bombing doctrine during the interwar period, rather than Gorrell's failure to sell the plan to his bosses during the war, which is the key issue here. The careful study of this plan at the Air Corps Tactical School (ACTS) in the 1920s and 1930s had clear implications for targeting and BDA requirements during World War II. Tiverton's focus on industrial target sets and “bottleneck targets,” adequate bomber concentrations, effective navigational techniques, and quality bombs and bombsights all became key components of American interwar bombing doctrine and wartime practice.

The Tiverton-Gorrell connection is important for three reasons. First, it demonstrates Tiverton's influence on subsequent American strategic bombing doctrine and practice, particularly since the “Gorrell Plan” was required reading for faculty and students at ACTS.¹⁵ Second, it helps us understand more fully why British and American bombing doctrine diverged, gradually during the interwar period, and then sharply during World War II, as Bomber Command moved from daylight precision to night area raids. Finally, and crucial for the purposes of understanding the development of BDA capabilities and procedures, it suggests, even if only implicitly, how important bombing doctrine, objectives, and campaign planning would be in the development of BDA procedures.

¹⁴ Gorrell Plan, in MM, Vol. 2, 141-142.

¹⁵ The narrative summary of the bombing survey was part of the ACTS curriculum, and the *Bombardment Aviation* manual (Langley Field, 1931), also cited the summary several times. See MM, Vol. 4, 504 and 561, note 3.

3.3 The Post-World War I Bombing Surveys and Wartime BDA Compared

Immediately after the end of the First World War, the British and Americans both sent bombing survey teams into western Germany to assess the effects and effectiveness of Allied bombing raids. The reports they produced, which corroborated wartime BDA reports with German reports of damage to the same targets, provide a superb means for checking the accuracy of wartime BDA reports.¹⁶ The two surveys were conducted independently of one another and involved visits to many of the same targets. Although the American survey report made it through the staffing process intact, the British survey went through three iterations before emerging in 1920 as Air Ministry Publication 1225, a document that in many ways bears little resemblance to the original submitted by the survey team. The original British survey, when studied in conjunction with the American version and German records of bomb damage, demonstrates that Allied bombing of Germany did very modest physical damage. In fact, bomb damage represented less than one-tenth of one percent of total war expenditures.¹⁷ Nor did it have an appreciable impact on German civilian morale, particularly as it influenced their willingness to continue the fight. The surveys also reaffirm the truism that aircrews provide inflated damage estimates, particularly if they are under fighter or anti-aircraft artillery attack. Given the disproportionate reliance on aircrew reporting for the majority of World War I bombing missions, wartime BDA reports tended to be rosier than postwar assessments.

As Major H. M. Major Paul, the British survey team leader, noted, damage to German-controlled marshalling yards and railways resulting from Allied bombing was at

¹⁶ The American report is printed in MM Vol. 4, 363-505 with endnotes on 561. The initial version of the British report is in AIR 1/1998/204/273/262, Major Paul to Air Ministry, 26 February 1919.

¹⁷ Williams, *Biplanes and Bombsights*, 246-247.

most moderate, although he also emphasized that severe damage had been done in several cases, including one instance in which a British bombing raid destroyed a fully-loaded ammunition train at the marshalling yard in Thionville, and several others where heavily-loaded railcars in packed sidings had been hit hard by British bombers. Further, he stated that putting a complete stop to railroad traffic supplying German armies in the Metz area would have been all but impossible for the relatively small bomber force assigned to the IF. In fact, such an operation would have required air attacks "carried out in great force, a number of points being attacked simultaneously" as well as bombs with significantly greater destructive power than the 230-lb. versions usually employed against railroad targets. Finally, Paul noted that German railroad officials, when asked about the bombing, referred to it as an annoyance that could not be ignored, resulting in a greater loss of work through air raid alarms rather than physical damage. Morale problems were real and in some cases significant, but in the case of railroad workers were largely nullified with an increase in wages. Taken together, Paul's assessment of the effects of British bombing of railways indicated that bombing, while not entirely ineffective, produced fairly modest results, and that there had been a tendency in wartime BDA to overstate the damage done to German targets.¹⁸

This reference to the tendency of wartime BDA reports to overstate damage to the target applies specifically to *physical* damage. Conveniently for Trenchard, quantifying morale effects is difficult at best. Despite this difficulty, both survey teams tried to do so.

¹⁸ British Bombing Survey, "Reports of British Bombing Raids on German Railways, Railway Stations and Railway Objectives, 1918," comp. Major H. Paul, 26 February 1919. This document has no page numbers, so the best way to reference it is to note section headings from which information in the text is derived. These are "The Possibilities of Complete Dislocation of Traffic," "General Conclusions," "Material Damage," and "General Opinion of the German Railway Authorities as to the Effect of Allied Bombs."

Based mostly on interviews with German civilians, what they discovered could not have been comforting to Trenchard. In fact, German reporting emphasized the limited effect bombing had on German morale. Unfortunately, the heavily edited final version of British bombing survey contained none of the original concerns about the likely ineffectiveness of morale bombing. Instead, it made outlandish claims about the morale effects of strategic bombing, referring to “the immense moral effect of our air raids into Germany” and the “indisputable proof of the efficacy of air raids during the period under review.” With respect to attacks on industrial facilities, the report asserted that “The material damage has been great,” when in fact it had in almost all cases been slight or nonexistent.¹⁹ The final report also said of German workers: “Constant alarms and raids ruined their nerves, in some cases for life...had the war continued a few months longer, a more or less total breakdown of labour at several of the Works might have been confidently expected.”²⁰ These reports, and many others saying the same kinds of things about the primacy of morale over material effects, ultimately made the morale of German civilians an alluring target for British airmen, particularly once the daylight bombing effort failed so utterly in the opening year of the Second World War.

This wishful thinking had important implications for the development of British BDA capabilities in the interwar period. First, it was by definition unnecessary as well as impossible to contest the results claimed for morale bombing since its proponents assumed that every weapon had an effect. Second, and for the same reason, it allowed proponents of morale bombing to rationalize any targeting scheme they might come up

¹⁹ AIR 1/2104/207/36, Air Ministry A.I. 1, “Results of Air Raids on Germany Carried Out by the 8th Brigade and the Independent Force, R.A.F. January 1st – November 11th, 1918,” January 1920, 1, 3,

²⁰ AIR 1/1999/204/273/269, “General Moral Effect.”

with. The consequences for BDA were obvious: since every bomb would have an effect, and every effect would be positive, no serious intelligence capabilities or analytical process would be required.

Perhaps the oddest thing of all with respect to the morale bombing recommendations in the 1920 (3rd) edition of the British bombing survey is the fact that Trenchard himself had concluded at the end of the war that strategic bombardment in any guise was wasteful of resources and unlikely to be decisive. Consequently, he concluded that morale effect, while useful, had not played a particularly significant role in the IF's bombing campaign. Yet when he became chief of the Air Staff in 1919 (a post he held until 1929), Trenchard changed his tune to one of enthusiastic support for morale bombing. As a result, "the Royal Air Force claimed to be able to do the impossible. Its planners neglected basic programs; for example, training in long-range navigation and bombing accuracy."²¹ Clearly, BDA also belongs on this list of things British airmen ignored in consequence of the hyperbole surrounding the British survey and its advocacy of morale bombing.

The American survey arrived at very different conclusions, and although the full report was misfiled and effectively lost until 1974, the executive summary made it to several locations, including the Air Corps Tactical School, where it exerted a major influence on the development of strategic bombing doctrine, and by extension BDA, in the interwar years and the Second World War.²² The report did point out the potential indirect effects of bombing, including loss of production due to time in air raid shelters,

²¹ Williams, *Biplanes and Bombsights*, 260.

²² U.S. bombing survey, in MM, Vol. 4, 504 and 561, note 6. Maurer Maurer, who edited *The U.S. Air Service in World War I*, discovered the full report in July 1974 during a research visit to the National Archives. A notice of the report was then included in "National Archives Microfilm Publication Pamphlet Describing M990, *Gorrell's History of the American Expeditionary Forces Air Service, 1917-1919*" (Washington D.C., 1975).

lower morale, and too little sleep; the cost of defenses such as air-raid shelters, AAA, and fighters; and the diversion of resources from offensive to defensive purposes.²³ It also arrived at some of the same questionable assertions as the British version: "It is certain that air raids had a tremendous effect on the morale of the entire people."²⁴ In every other respect, however, the American survey arrived at startlingly different conclusions. To begin with, it criticized the British IF's "lack of a predetermined program carefully calculated to destroy by successive raids those industries most vital in maintaining Germany's fighting forces."²⁵ In other words, the American report was critical of the British failure to bomb each target in turn until it was destroyed or seriously degraded, a criticism Lord Tiverton would have agreed with entirely. It concluded by stating that

the enemy's morale was not sufficiently affected to handicap the enemy's fighting forces in the field...Bombing for morale effect alone...which was probably the excuse for the wide spread of bombs over a town rather than their concentration on a factory, is not a productive means of bombing. The effect is legitimate and just as considerable when attained indirectly through the bombing of a factory.²⁶

Finally, and most significantly, the American survey noted that bombing effectiveness against an enemy's war industries required a "careful study" of those industries, their interrelationships, and their vulnerabilities, followed by concentrated bombing of key industries and "bottleneck targets." The survey recommendations are worth quoting at length here because of the clear implications for BDA:

A careful study should be made of the different kinds of industries and the different factories of each. This study should ascertain how one industry is dependent on another and what the most important factories of each are. A decision should be reached as to just what factories if destroyed would do the greatest damage to the enemy's military organization as a whole. On these factories the entire

²³ Ibid., 495-496.

²⁴ Ibid., 498-499.

²⁵ Ibid., 501-502.

²⁶ Ibid.

available bombing force should be concentrated *until it is satisfied that the factory is crippled*. Once the plan of bombardment is chosen it should be held to religiously and a choice of immediate targets affected only by weather conditions and airplanes available. Factories should be bombed night and day successively as far as the weather will permit *until the desired results are thought to have been accomplished*.²⁷

The italicized portions of the text relate directly to the question of BDA, and although the requirement is implicit, it is basic to the success of the entire enterprise as it was outlined and recommended in the survey. The fact that the officers conducting the survey were intelligence specialists who understood the BDA process as it had developed in 1917-18 is significant. Clearly, they recognized the value of damage assessments.

The American advocacy of systematic and heavy bombing of German war industry *target by target* during the interwar years, and the belief that morale bombing for its own sake was ineffective, were the two most important consequences of the dissemination of this American postwar bombing survey. In fact, training courses at ACTS, the development of Air War Plans Division Plan 1 (AWPD-1) and its successor, AWPD-42, and American conduct of the World War II bombing campaigns all underscore the degree to which American airmen came to support the ideas reflected in the survey.²⁸

The implications of the postwar bombing surveys for both the British and the Americans are clear. Whatever incentive the British might have had to retain a substantive BDA capability largely disappeared in the wake of the 1920 version of the British bombing survey. However, given the extreme fiscal austerity of the immediate postwar period, it is anything but clear that a real BDA capability would have survived or

²⁷ Ibid., 502. Emphasis added.

²⁸ AWDP-1, written in the summer of 1941, was technically a requirements document stating the numbers of aircraft, personnel, and other assets required for a wartime air effort. It was also a *de facto* air plan for the aerial bombardment of Germany, something General Arnold and his subordinates included by design.

developed even had the survey arrived at different conclusions. The American report is a case in point. Despite the survey's findings in favor of precision daylight bombardment and against morale bombing, most of the required BDA infrastructure—including the training and organizations to support such a process—disappeared almost immediately after the end of the war and did not reappear until the next war. Yet the precedent for BDA had been set in the final months of World War I, and the summary of the American bombing survey, which made its way into the ACTS curriculum, forced American airmen to think, even if only fleetingly, about *how* they would go about assessing the damage done to enemy war industry in a future conflict.

Ironically, the most detailed BDA in both surveys came from *German* damage reports compiled during the war. Published in summary form in 2000, they corroborate the American survey team's conclusion that bombing results were modest at best. Of the 15,700 bombs dropped on Germany, half were dropped in 1918. The bombing killed 740 people and injured 1,900.²⁹ The German General Staff noted that bombing had little physical or morale impact on civilians. In fact, Germans regularly ignored air raid warnings, going about their daily business, or watched—without taking cover—as British bombers droned overhead. The vast majority of casualties came as a result of this habit. Once people began taking shelter, casualties dropped to almost zero. In ten of the largest raids of July 1918 the Germans suffered not a single casualty. Yet the British chose to

²⁹ Christian Geinitz, "The First Air War Against Noncombatants: Strategic Bombing of German Cities in World War I," in Roger Chickering and Stig Förster, eds., *Great War, Total War: Combat and Mobilization on the Western Front, 1914-1918* (Cambridge University Press, 2000), 207.

ignore this evidence.³⁰ As one scholar notes: "What the Air Ministry characterized as panic was mainly a demand for prompt payment of insurance claims."³¹

One other crucial issue relating to German BDA reports is worth noting here. Although the British and Americans did not have access to German reports until after the war in this instance, the story would be very different in World War II. Capitalizing on ULTRA intercepts of German messages containing damage reports, and on records of damage compiled by the Germans and other officials in Italy, France, Belgium, and western Germany, which were captured during the Allied advance, Allied intelligence officers were able to determine with great accuracy the degree of damage wrought on German industry by the heavy bombers of RAF Bomber Command and the U.S. Strategic Air Forces in Europe. This use of the *enemy's* damage reports *during the course of the war* to determine the effects and effectiveness of the Allied bombing effort marks one of many stark differences between the embryonic state of BDA in World War I and its mature state in World War II. In short, Allied photographic intelligence, Ultra intercepts, and damage reports produced by Italian, French, Belgian, and German officials combined in synergistic fashion and also resulted in an iterative learning process that allowed the Allies to improve their bombing effectiveness from one campaign to the next.

3.4 Conclusions: The State of BDA at the End of the First World War

British and American experiences with bombing during World War I, and the very different conclusions they drew from them, drove the development of divergent ideas about BDA in the final months of the war. These ideas, most of which would be

³⁰ Biddle, *Rhetoric and Reality*, 60-62.

³¹ Williams, *Biplanes and Bombsights*, 250.

relegated to the subconscious and lie dormant during the interwar period, reemerged with incredible speed and vitality at the end of the interwar years and in the early stages of World War II. As one scholar notes, air officers from both countries shared the same underlying belief about the potential efficacy of bombing: "A fundamental assertion that became central to Anglo-American thinking about long-range bombing was that modern, complex, urban-based societies are fragile, interdependent, and therefore particularly vulnerable to disruption through aerial bombing."³² However, after a brief and unsuccessful daylight bombing effort in 1939 and 1940, the British used this assertion as justification for their World War II night city-bombing campaign to destroy Germany's urban areas and in the process undermine German morale. In contrast, the Americans arrived at a very different solution: high-altitude, precision, daylight bombardment. Consequently, it is here that we would logically assume a fundamental divergence in BDA emphasis and procedures during the interwar period and World War II. Yet there was none. Neither side continued developing any kind of serious BDA capability in the years after World War I. In this respect, BDA developments in the two countries were similar. Even more ironic and unexpected is the fact that the British, once they began to pay serious attention once again to strategic bombing after 1936, actually adopted Tivertonian rather than Trenchardian targeting and BDA ideas and developed capabilities in line with them. Just as surprising was the British effort to conduct daylight, precision bombardment during the first year of World War II. And most startling of all, as will become clear in Chapter 5, is the fact that the British shift from daylight, precision, to night, area bombing produced no significant changes in their highly developed

³² Ibid., 7.

Tivertonian BDA capabilities. What this meant, quite simply, is that a marvelous British BDA capability came to be paired first and foremost with the *American* daylight, precision bombing campaign, a campaign it was supremely well fitted to support. This serendipitous relationship between British BDA capabilities and American bombing doctrine would have dramatic implications for the conduct, effectiveness, and assessment of the Allies' heavy bomber campaigns during the Second World War.

CHAPTER 4

RETRENCHMENT AND ADVANCE: BDA IN THE EARLY INTERWAR PERIOD, 1919-1933

4.1 Context: The Retreat of All Things Military

The end of the Great War brought with it a host of issues that undermined the BDA intellectual infrastructure that had emerged in 1917-18. Foremost among these were profound exhaustion and a deep revulsion towards war that accompanied the Armistice. Hard on their heels came pacifism, low military budgets, isolationism in the United States, and a quasi-isolationism in the United Kingdom defined by an unwillingness to consider committing another large army to any future war on the Continent. These key contextual factors dominated events and set political agendas on both sides of the Atlantic. Accompanying this host of issues was an economic fragility in Great Britain and a turning inward in both countries that resulted in their partial absence from the affairs of Europe for the next two decades. In the United States, a focus on hemispheric security and the belief that the country faced no major threats in the 1920s and early 1930s—both reasonable conclusions given the nature of the international community during that period—resulted in a military austerity that only deepened once the United States plunged into the Great Depression. In Great Britain, particularly after 1930, the

twin influences of Limited Liability and the Ten Year Rule, in addition to the extreme fiscal austerity of the Great Depression, had a similar effect on military expenditures.¹

At the same time, the League of Nations, dedicated to upholding a peaceful world order in the wake of the Great War, and several countries involved in the various disarmament conferences it sponsored, sought to outlaw aerial bombardment altogether. The three schools of thought within which these discussions occurred were those dedicated to a complete abolition of all military aviation, a prohibition of all aerial bombardment, and a conditional (partial) prohibition of aerial bombardment.² Needless to say, neither Great Britain nor the United States was willing to sign on to any of these schools of thought, first and foremost because their geographical positions and interwar grand strategies made airpower, and particularly bombers, crucial to the defense of their territory and population. Civilian and military leaders in these two countries were also intelligent enough to recognize that, should another war begin, bombers might represent

¹ Limited Liability was a British policy decision to limit costs and manpower losses in a future war by engaging in blockade and peripheral warfare rather than committing another large army to the Continent. The Ten Year Rule was a planning and programming tool the British used to determine force structure, weapons-development programs, and other military outlays based on the likely international environment in the coming decade. Both had a negative influence on British military preparedness. Two excellent works dealing with the interwar contexts in Great Britain and the United States are Williamson Murray, "The collapse of empire: British strategy, 1919-1945," and Eliot A. Cohen, "The Strategy of Innocence? The United States, 1920-1945." They comprise Chapters 13 and 14 in Williamson Murray, MacGregor Knox, and Alvin Bernstein, *The Making of Strategy: Rulers, States, and War* (Cambridge, UK: Cambridge University Press, 1994). Also excellent in providing the larger context is Sir Charles Webster and Noble Frankland, *The Strategic Air Offensive against Germany, 1939-1945, Volume I, Preparation* (London: Her Majesty's Stationery Office, 1961), 52-64. They noted that the international environment of the 1920s and early 1930s, along with a revulsion against war, produced an under-investment in aircraft development and procurement. "In these circumstances," they said, "it is not surprising that...little progress was made in solving the technical and intricate problems of strategic bombing." (p. 60)

² See, for instance, AIR 5/192, "Proposals in regard to aerial bombardment submitted to the Air Sub-Commission of the League of Nations by the Chinese Air Delegation," 1 August 1922, in which the British essentially fended off Chinese proposals to provide an evacuation period for civilians and limits on areas open to aerial bombardment. In an Air Staff Minute located in AIR 5/192, "Rules as to Bombardment by Aircraft," 15 July 1922, the British quite sensibly disagreed with the Chinese proposals because an evacuation period for noncombatants would also alert defending air force and antiaircraft artillery units.

their only effective *offensive* weapon, particularly early in the conflict, which was in fact exactly what happened in the case of the British. And there was another, equally important reason for the persistence of the *idea* of bombing, and its eventual reality, in the Anglo-American camp: "Perhaps," noted Richard Overy,

it is no coincidence that strategic bombardment was embraced wholeheartedly before the Second World War by the two states in which industrial society was most fully developed and in which the planning and preparation for war relied much more on civilian initiative and a close collaboration of the politicians and industrialists.³

The exact same thing might be said of the development of BDA to support the bomber forces both countries eventually produced to carry the war to Germany.

Of course, the most basic problem with any plan to eliminate or restrict air power in general, and bombers in particular, was the inability to enforce such a scheme without the full commitment and honesty of all the signatories—a highly unlikely possibility. These efforts to limit air warfare came to naught, but they underscored a broad sentiment during most of the interwar period that bombers and bombing were distasteful and not to be embraced openly or enthusiastically. The only caveat to this set of developments—and it is an important one—is that both American and British airmen continued to pursue a long-range bombing capability, a trend particularly noticeable in the U.S. Army Air Corps during the 1930s. The British Secretary of State for Air summed up the British view when he warned of the

grave dangers to the defense of this country and of the Empire...I have always urged that prohibition of bombing will only provide an *illusion* of security, in so far as the civil population is concerned. It is certain to be disregarded in war, and, when this

³ R. J. Overy, "Strategic Bombardment before 1939: Doctrine, Planning, and Operations," in R. Cargill Hall, ed., *Case Studies in Strategic Bombardment* (Washington, D.C.: Air Force History and Museums Program, 1998), 74.

occurs, no rules for the conduct of bombardment will exist to shield the civil population from the effects of *indiscriminate and unrestrained bombing*.⁴

Nonetheless, neither British nor American airmen began once again to grapple seriously with the question of the strategic application of aerial bombardment until the early 1930s, and given the overarching contextual factors described earlier, the surprise is not that the nascent intellectual infrastructure for BDA withered away, but rather that several of its component parts remained, and that there were in fact a number of impressive advances, including first and foremost the development of excellent new aerial cameras, film, and related technologies and techniques for both day and night use. There was an equally impressive advance in aircraft during this period, and by 1939 the aircraft that came to epitomize the photoreconnaissance effort during the Second World War—the Supermarine Spitfire—had emerged and would before the end of that year begin its distinguished career and as a collector of aerial photographs crucial to the Allied war effort. In addition, the air intelligence profession, including a critical mass of photography and photointerpretation officers, survived—if only barely—between the wars. Even the development of new bombs and fuses proceeded slowly but steadily.

In assessing the retrenchment and subsequent advance of the intellectual infrastructure, two distinct periods present themselves. The first, lasting from the Armistice until the accession of Adolf Hitler to power in Germany in January 1933, saw the dissolution of the infrastructure into a collection of surviving component parts that

⁴ AIR 8/103, Cabinet, "Note by Secretary of State for Air on Air Disarmament Policy," 30 July 1932, 4. Emphasis in original. See also AIR 8/103, Cabinet, "Note by Secretary of State for Air," 4 November 1933, 3, which stated that "The Case of Germany deserves special mention. Prohibition of air bombardment will do nothing to dissuade Germany from claiming an air force. On the contrary, she intends to use it as the strongest argument in support of her claim to be allowed what may then be termed a 'non-aggressive' air force."

either continued their development or merely persisted, but did so for the most part in isolation from one another. Once Hitler came to rule Germany, a second and much more intense period of military developments began in Great Britain and the United States, as Nazi Germany's shadow, and then its rule, spread across central Europe from 1936 to 1939. The British responded to these ominous developments by building on several economic and air intelligence organizations they had established in the 1920s and early 1930s. The two most important were the Committee of Imperial Defense's Advisory Committee on Trade Questions in Time of War (ATB), founded in December 1923, and its Industrial Intelligence Center (IIC), established in 1931. The British built on these during the late interwar period by establishing the Joint Chiefs of Staff's Joint Intelligence Sub-Committee (JIC) in June 1936, and then by subsuming the ATB and IIC within the Ministry of Economic Warfare (MEW) in September 1939. This ministry would play a key role in the BDA process during the Second World War. There was, in addition, a major expansion of the Air Ministry, including the reemergence of a dedicated Directorate of Intelligence, which worked increasingly closely with MEW as war approached and after it began. One of its new offices, R.D. Arm. 4 (Analysis of Bombing Results), was dedicated to analyzing the results of British practice bombing at RAF bombing ranges and ultimately became involved in developing effective BDA procedures for determining the effects and effectiveness of British bombing. During the same period, the Air Ministry established several functional boards, including the Bombing Committee, active from January 1934, which began setting forth the requirements for creating a heavy bomber force capable of inflicting serious damage on Germany's war economy. These developments during the late interwar period, as we

shall see in the next chapter, marked the reemergence of perhaps the most vital element of the BDA intellectual infrastructure: civilian and military organizations dedicated to targeting and BDA functions, all of which began to work with one another, sharing information and along the way determining which of them were best equipped to carry out the various functions in this reemerging infrastructure. This process was at first turbulent, given the uncertain extent of each organization's responsibility for air and economic intelligence and the consequent "turf wars" to establish areas of authority, but as it gathered momentum, and the intelligence personnel involved gained experience and a deeper understanding of their role in the emerging targeting and BDA processes, an impressive set of capabilities began to emerge.⁵

4.2 Retrenchment and Advance in the Early Interwar Period, 1919-1932

When the Great War ended, the component parts of the nascent BDA intellectual infrastructure either ceased to function or went their separate ways, surviving on the sparse diet of interwar tasks and funds allotted to them by impoverished and war-weary governments. In most cases, assuming a component element of the infrastructure survived at all, it did so by performing functions which, on the surface, appeared to have little or nothing to do with BDA, a process linked in the public's mind to bombing, which was itself widely viewed during the interwar period as an instrument of aggressive war

⁵ The best account of the development of these key British intelligence organizations before the war and immediately after it began is F. H. Hinsley et. al., *British Intelligence*, Vol. 1, 100-102. See AIR 5/1143, "Bombing and Air Fighting Committees, Interim Reports, January 1934-December 1938, 2. The First Interim Report, September 1936, 1-2, stated that "The Bombing Committee was formed in January 1934, for the purpose of achieving a better measure of coordination between the development of bombing methods and tactics, and the development of equipment required for their efficient application." Members of the Bombing Committee included the Deputy Chief of Air Staff, who chaired the committee, and 11 other Air Ministry officers, including a representative from R.D. Arm. 4. (Analysis of Bombing Results); the Bomber Command Senior Air Staff Officer and Senior Armament Officer; the Air Officer Commanding, Air Armament Group; RAE (Research and Experiments Section at RAF Farnborough); and three Admiralty representatives.

and thus one to be suppressed. As a means for gauging the degree to which these interwar currents affected the air intelligence manpower picture, consider the case of the Air Ministry Directorate of Intelligence. From a wartime organization in which the Chief of Air Staff (CAS) had nine people in his front office, the Director of Flying Operations (DFO) 13 (one of whom was Lord Tiverton), and the Air Intelligence Directorate 33 (including 11 in A.I.1, the Bomb Raids and Targets Section), the Air Ministry's key Directorates shrank to 4 people in the CAS front office and a total of 15 in DOI (an amalgamated office combining the duties of the wartime DFO and AI—with seven officers on the Operations side and eight on the Intelligence side). Nonetheless, the more significant and less obvious side of this development was that AI, although amalgamated within DFO and reduced substantially in terms of manpower billets, survived to provide a nucleus around which the air intelligence officers of the Great War could gather once again when called back to service in the late 1930s.

On a less sanguine note from the American perspective, with the dissolution of GHQ AEF in 1919, and its constituent Air Staff, the only American air intelligence organization then in existence simply disappeared, not to be glimpsed again until the Army Air Corps Act of 1926 made provision for a G-2 Air Branch (which later became a larger and more capable G-2 Air Section), and the creation of a small Intelligence Section within GHQ Air Force when it was created in March 1935. This latter development occurred, in spite of War Department G-2 objections, because the GHQ Air Force leadership insisted that their mission to deploy air power immediately upon the commencement of hostilities required that they have at least a reasonable level of intelligence relating to potential adversaries. This, of course, meant an organic air

intelligence capability, and the airmen's insistence on this point proved successful, even if the resulting capability was meager.⁶

Despite the large and seemingly disastrous manpower cuts in both the British and American air arms during the immediate Post-World War I period, doctrinal developments were anything but retrograde, especially in the U.S. Army Air Corps. In fact, American doctrine proved particularly vibrant from the early 1920s until the United States entered the Second World War. The common view among historians of airpower that American ideas about high-altitude, precision, daylight bombardment represented "a doctrine in search of an airplane"—a search that ended with the fortuitous pairing of bombing doctrine with the B-17 heavy bomber—something similar might be said about the emerging relationship between bombing doctrine, targeting, and BDA during the interwar period. If the British proved better at determining the interrelationships between the three, the Americans were the undisputed leaders in doctrine development.

4.3 Doctrinal Development: The American Experience

Not surprisingly, the first American airman to advocate strategic bombing, and BDA as its vital adjunct, was none other than Lieutenant Colonel Edgar S. Gorrell, the officer who had borrowed Lord Tiverton's bombing theories whole-cloth and advanced them as the template for future American air warfare. In a piece he wrote just after the end of the war as an instructional guide for American airmen, Gorrell began, not surprisingly, by comparing aerial bombardment and artillery, noting that "The conceptions spoken of in this paper are not new, since they represent for the Air Service the same phase of

⁶ AIR 1/2087/207/8/37, 330-337, Air Ministry Memo, Manpower Documents, 3 June 1918 and 25 November 1919. For a good discussion of these embryonic American air intelligence capabilities, see Kreis, *Piercing the Fog*, Chapter 1, "Early Intelligence Organization in the Army Air Corps," 17-24.

development along well defined lines, and with approximately the same proportionate increase, as has been true of artillery..." the lessons from which, he continued, "...apply exactly to the aviation situation when we consider the questions of the aerial bombardments to be effected in the future."⁷ He also maintained his earlier view that the most vital role of bombers was in direct and indirect support of ground armies in the zone of the advance. In a particularly prescient passage, Gorrell asked, rhetorically,

What would happen if the artillery [in this case aircraft] were able to prolong and intensify its fire on the important objectives in that zone where occurs the ebb and tide of the extensive maintenance and replenishment which now goes on in all security from our attack? What would happen if bases of communication were destroyed, supplies of rations and materiel cut off for several days, if reserve troops were subjected to the demoralizing effect of fire without defense or repartee being possible? The bombardment airplane should be looked upon as a long-range gun capable of doing what the fixed artillery cannot manage...⁸

From there, Gorrell turned to a more detailed discussion of bombardment aviation's role in what we today would call battle area (or "deep") interdiction. Gorrell discussed the future value of bombers as platforms for attacking an enemy's lines of communication. Even more important, though, was his emphasis on the destruction of industrial centers in the zone of the enemy's interior where his munitions, rations, and other supplies were produced. These, he reiterated, were the sinews of war, the fundamental materials that enabled an enemy's army to keep fighting.⁹ This attack on enemy industries marked the hinge between what Gorrell referred to as tactical and strategical aviation. The latter, he reminded his readers, "is mainly at long distances and is an integral part of the offensive... The basic purpose is to weaken the power of the

⁷ AFHRA 248.222-7B, Colonel E. S. Gorrell, "The Future Role of American Bombardment Aviation" (1919), 2-3.

⁸ Ibid., 4-5.

⁹ Ibid., 6.

enemy both directly and indirectly; directly, by interrupting his production, transport and organization through the infliction of damage on his industrial, railway and military centers and by compelling him to draw back his fighting machines [fighter aircraft] to deal with the enemy's; indirectly, by producing discontent and alarm among the industrial population. In other words, it aims at achieving both a material and a moral effect." Gorrell further stated that for strategic bombardment to have the maximum effect, "visits must be constantly repeated, at short intervals...for it is this recurrent bombardment, as opposed to isolated and spasmodic attacks, which interrupts industrial production and undermines the public confidence."¹⁰

Much has been made, in this work and others, of the fact that Gorrell's ideas were really Tiverton's, which Gorrell borrowed for his own purposes. Be that as it may, Gorrell's writings received wide circulation among airmen at the Air Corps Tactical School (ACTS) and elsewhere during the 1920s and 1930s, and they took hold with a tenacity difficult to overemphasize. What has been less noted, however, is that Gorrell's focus was first and foremost on providing decisive assistance to ground armies by way of aerial bombardment, and that his exposition on strategic bombing in effect emphasized its potential influence on three levels of war: the military strategic, the operational, and the tactical. This idea that bombers should engage in operations of the greatest benefit to the advancing ground armies, took root among interwar American airmen, even those such as Arnold and Spaatz who were later accused of being airpower zealots, and while they at times implied and certainly hoped that strategic bombardment might prove decisive on its own, they never turned their backs on Gorrell's fundamental idea that bombers could do a

¹⁰ Ibid., 14-15.

great deal *in conjunction with* ground forces. This had major implications for the target sets advocated by American airmen during the Second World War. It is worth remembering, for instance, that General Spaatz pushed for the oil offensive in the spring of 1944 *explicitly* to assist not only Anglo-American armies, but even more importantly the Russian army in its death struggle with the German foe. Gorrell's ideas reverberated throughout the interwar period, were inculcated in American airmen and written into American bombing doctrine, and therefore had vital implications for targeting and BDA development in the late interwar period and during the Second World War.¹¹

The degree to which Gorrell's ideas took hold became evident almost immediately in the Air Service's first doctrinal manual on bombardment aviation, published in 1923 under direction of the Office of the Chief of Air Staff. The manual divided bombing targets into three categories, including naval forces, land forces, and assets in "the interior zone of the enemy." Gorrell's influence on this publication, whether direct or indirect, is clearly in evidence here. Targets in the latter category included mobilization and training centers; transportation centers; bridges, dams, locks, power plants, and tunnels; war material depots; and industrial centers. "The attack of military objectives in the interior zones of the enemy," the manual said,

provides a mission for bombardment aviation which cannot be performed by other combatant forces. The importance of such operations cannot be overestimated, not only as regards the physical destruction that is accomplished, but also as regards the tremendous moral effect attached to such operations. Both day and night bombardment will be employed against these targets.¹²

¹¹ See AIR 37/1125, USSTAF, "Employment of Strategic Air Forces in the Support of OVERLORD," 24 March 1944, 2-3, in which Spaatz argued explicitly in favor of an oil offensive to deprive the Germans of fuel on the decisive Eastern Front as well as the Western and Italian Fronts.

¹² AFHRA 248.222-44A, "Bombardment Aviation," prepared under direction of the Office of the Chief of Air Staff, 1923, 2, 6-8.

Equally noteworthy, in view of this focus on targets deep in the enemy's country, was the emphasis on air intelligence as the means for determining which targets to attack and gauging the effects and effectiveness of those operations. "In each organization of a bombing force," the manual noted, "there will be a thorough and systematic method of collecting and disseminating all information which can be made of value. This function is performed in Air Service units by air intelligence sections."¹³ This intelligence included the following broad categories:

- (1) Location and military importance of bombardment objectives.
- (2) The effects of bombardment raids on targets.
- (3) The strength, disposition and location of enemy artillery forces and airdromes.
- (4) The strength and disposition of enemy ground defenses against aircraft.
- (5) The ground organization for aids to navigation, such as lighthouses, bombs, etc.
- (6) All additional information concerning activities or locations of the enemy.

It thus becomes clear that the top two categories of intelligence to be collected were for targeting and BDA. The requirements for both were explicit and marked the first point during the interwar period in which an American Air Service doctrine document placed such a clear and unequivocal emphasis on these two vital categories of air intelligence.

A closely related training regulation codified these doctrinal principles and provided additional insights on evolving American ideas about aerial bombardment. It began with a mission statement for bombardment aviation: "The mission of bombardment aviation is, like all other offensive forces of a nation, to utilize its power within its utmost capabilities toward the defeat of the enemy."¹⁴ The emphasis was clearly on offensive action. This *idea* that bombers should be used offensively, and in conjunction with land and sea

¹³ Ibid., 8.

¹⁴ AFHRA 218.222-39, Air Service Training Regulation No. 400-95, "Bombardment Aviation," 1923, 2.

power, never disappeared from American doctrine documents. The proof of this lay in the continuing development of bombing doctrine during the late interwar period, which gave clear primacy to offensive bombing carried out by heavy bombers such as the B-17.

The principles for employment of bombardment aviation, also detailed in this training document, included a number of admonitions that came straight from Lord Tiverton and, through Gorrell, to the Air Service and later the Air Corps:

- (1) Only employ a bombing force in accordance with and furtherance of the definite tactical or strategical plans. Aimless or haphazard bombing is to be avoided.
- (2) To carefully select targets (considering the importance and vulnerability) and attack only those that offer a reasonable degree of success. Failure raises the enemy morale and correspondingly demoralizes the bombing force.
- (3) Thorough preparation of all plans of employment must be judiciously made, as the ease with which it can be placed into operation subjects this arm to hasty and faulty employment.
- (4) Bombing attacks must be thorough and carried to their completion. Complete destruction of targets must be accomplished and day and night bombing must be continuous until definitely terminated. Only by such means can the maximum amount of demoralization which bombing is capable of producing be obtained.
- (5) The maximum amount of bombs selected should be used in each case, to insure complete destruction and to create the fear that leads to demoralization.
- (6) Detachments, constituting as they do, a detriment to all arms, are particularly so, owing to the high degree of technicality, to bombing units and must be avoided.
- (7) A practical and accurate knowledge of the capabilities of a bombing force is most essential, as a failure to apply it at the proper time and in the correct manner may be the determining factor between success and defeat.¹⁵

The document continued with the statement that

In battle a bombing force presents a means whereby a commander may extend his theater of operations to practically any desired depth into the enemy territory, where without a bombing force his interference with enemy activity ceases with the range of his heavy artillery...The role of a bombing force in battle would be to destroy means of communication and transportation, thus preventing evacuation and renewal of forces and supplies, also to destroy all materials, depots and airdromes, continuing this destruction into the strategical areas during this period.¹⁶

¹⁵ Ibid., 23-24.

¹⁶ Ibid., 25.

In other words, the focus was on an effective integration of airpower into an overall military campaign—one in which the senior airman attacked targets likely to produce the greatest effects in conjunction with the actions of the ground commander and his subordinate forces, and therefore one calculated to make bombardment aviation as effective a military instrument as possible in *combined-arms* operations.

The seven principles of employment listed above had significant implications for the development of targeting and BDA. Bombers were to be used only in accordance with a clear strategy in which vital objectives were attacked with a maximum synergy between ground and air units. Target selection and other aspects of air-campaign planning were to be engaged in judiciously and carefully, with an eye towards choosing target sets likely to cause the enemy the most grievous harm. Bombing was to be concerted, intensive, and not stopped until the key target sets were destroyed or so severely damaged as to be largely useless to the enemy. A deep knowledge of the available bomber force, including its capabilities as well as its limitations, and a sense of proper timing on the part of senior airmen as to when attacks on an enemy target set would be likely to cause the greatest harm, might make the difference between success and failure. This idea that intuition and timing—concepts addressed by Clausewitz in some detail—were vital to aerial bombardment was very much in evidence during the major Allied bombing campaigns in 1944-45. Finally, although not specifically stated, excellent BDA would be required to gauge accurately the effects and effectiveness of these concerted bombing efforts.

That these very Tivertonian concepts appeared so prominently in an Office of Chief of Air Staff doctrine document, and in its twin, a training regulation read by hundreds of Air Service officers (and which was in reality a thinly veiled doctrine document), made

clear the extent to which offensive, precision bombardment operations against key targets sets *as part of a larger combined-arms effort* had taken root in the American air arm by 1925. The aspect of this doctrine most uniquely American was the emphasis on effective joint operations and the vital role that bombers could play in furthering overall objectives by attacking targets most likely to give ground forces the greatest possible advantage. Tiverton had seen this possibility in his advocacy of concerted attacks on the German munitions industry, but it was the U.S. Strategic Air Forces in Europe (USSTAF), and later Bomber Command, that would make the concept a reality in 1944-45.

Although some American advocates of the bomber edged away from this idea of an integrated strategy to a greater or lesser degree later in the interwar period, the connection never disappeared entirely. Even William C. Sherman, the Air Service bomber advocate who in 1926 authored one of the first comprehensive texts on air warfare, took care to tie the employment of heavy bombers, and their effects on the enemy's war economy, to the ground campaign. In his assessment of the importance of bombing an enemy's war industry, he asserted that "We are accustomed to think of war as being decided only on the battlefield, and indeed this is true...But industrial efficiency can give to its possessor a tremendous advantage, when at length he arrives on the battlefield. Accordingly the destruction of an enemy's industries assumes a tremendous importance."¹⁷ Similarly, Sherman envisioned air attacks on enemy lines of communication, especially railroads, as a task for both heavy bombers and attack (fighter-bomber) aircraft. The former, he argued, had the most important mission, namely, the destruction of major marshalling

¹⁷ William C. Sherman, *Air Warfare*, Reprint Edition (Maxwell AFB, AL: Air University Press, April 2002), 198.

yards, bridges, and viaducts, while the latter would concentrate on attacking moving trains. By destroying marshalling yards and thus pushing back the railheads further and further from the front lines, heavy bombers could precipitate a major supply crisis for the enemy army. Sherman therefore related this bombing effort directly to the effects it would have on enemy ground forces and therefore on the increased effectiveness it would give to friendly armies, emphasizing "the vital importance of lines of communications, and the disaster that may follow upon their destruction..."¹⁸ Taken together, Sherman's views of the future role of bombardment aviation were remarkably accurate and presaged the disaster that befell German armies in the field as a result of the Allied transportation and oil offensives in 1944-45.

In two other key respects, these closely-related doctrine documents conformed to Gorrell's ideas about aerial bombardment, stating that "The moral effect of successful bombardment is tremendous and is equal to if not greater than the actual physical damage that can be wrought. This potential power is real and, coupled with its power of destruction and the dissipation of enemy energies which it causes, makes a bombardment force a vital factor in the success of any army."¹⁹ The emphasis on morale effect, although subordinate to physical effects in American bombing doctrine, was nonetheless present as a junior partner and exerted a limited if real influence on the development of bombing doctrine. More important, however, was the assertion that bombers would comprise "a vital factor in the success of any army." Once again, the emphasis was on aerial bombardment as a force multiplier for the army, a theme both constant and vital but

¹⁸ Ibid., 200.

¹⁹ AFHRA 248.222-44A, "Bombardment Aviation," prepared under direction of the Office of the Chief of Air Staff, 1923, 8-9.

largely overlooked by scholars. The incendiary claims for airpower as a decisive instrument in its own right by interwar airpower theorists such as Douhet, Trenchard, and Mitchell had, in this sense, a profoundly negative influence in that they obscured the older, more sensible, and more palatable idea (from the army's perspective) that bombers should, first and foremost, support the advance of ground forces. This might be accomplished through tactical and operational means, including close air support and battle area interdiction, and it might be accomplished through military-strategic means, such as the destruction of the enemy's munitions plants, transportation infrastructure, or, later, his oil plants. These were not objectives for their own sake. Rather, they were to be conceived and executed in support of a combined-arms strategy designed to maximize the effectiveness of one's own army while minimizing that of the enemy. To paraphrase Clausewitz, they had their own grammar but not their own logic. This is perhaps the most important lesson we can draw from these early interwar bombardment regulations, and the most useful reminder they give us, namely, that the majority of the Allied bombing campaigns during the Second World War, and the targeting and BDA that supported them, were designed to get Allied armies to the Reich as quickly as possible, at the lowest possible cost in blood and treasure, and with the greatest possible maneuver and firepower advantages. Indeed, this was the essence of bombing doctrine during the interwar period and of bombing operations in World War II, a crucial point too often obscured by the inflammatory, counterproductive, and pointless conceptions of air forces and armies as adversarial rather than intertwined and equally important elements of the Allied war effort. Equally obscured by this continuing and unnecessary debate were the central roles of targeting and BDA in giving Allied senior airmen the intelligence

required to steer their bomber crews to the most lucrative targets—those whose destruction would pay the biggest dividends for advancing Allied armies.

The notable exception to this idea that bombers and armies were complementary developed at ACTS during the period between 1927 and 1934, when a group of zealous bomber advocates on the faculty argued that “Proper selection of vital targets in the industrial/economic/social structure of a modern industrialized nation, and their subsequent destruction by air attack, can lead to fatal weakening of an industrialized nation and victory through air power.”²⁰ This approach to air warfare, while convincing to some airmen, was absolutely unconvincing to senior Army officers who had their background in ground combat, and these were the men who led the American war effort from 1941 to 1945. Most of them came to recognize the decisive role airpower could play, in conjunction with ground forces, but they never allowed airpower zealotry to determine the nature and course of bombing, and in fact most senior airmen felt the same way. In this sense, while we should view doctrinal developments at ACTS between 1927 and 1934 as important, we must not be lulled into believing that anything but a minority of American military officers, none of whom would direct the American war effort, held these extreme views of the potential of American airpower.

What the ACTS bombing zealots *did* do effectively was to make well known and generally acceptable the proposition that concerted attacks by heavy bombers on key target sets within industrial and military infrastructures could cause grievous harm to an enemy’s war effort. Once again, their wording was too strong—“Disruption or paralysis

²⁰ Quoted in Haywood S. Hansell Jr., *The Strategic Air War against Germany and Japan: A Memoir* (Washington D.C.: Government Printing Office, 1986), 10.

of these systems undermines both the enemy's *capability* and *will* to fight"—but the idea that bombers could accomplish a great deal was ultimately embraced by senior officers with more balanced views of the potential of bombers and their proper employment in conjunction with land forces. General Carl Spaatz was one such man, as was the RAF's Air Marshal Norman Bottomley. Together, they exercised executive authority over the Allied bombing effort from late September 1944 until the end of the war, and they did so in very close cooperation with General Dwight D. Eisenhower, the Supreme Allied Commander, focusing their bombers on transportation and oil targets of the greatest value to Germany's war effort, in particular to her ground and air forces. In doing so, they continued a process that began in the summer of 1943 with the bombing of rail centers in support of Allied landings in Sicily and southern Italy. The process accelerated in March 1944 with the transportation campaign against railroads in France and Belgium, which sought to isolate the Normandy battle area from German reinforcements and re-supply.

During the development of bombing doctrine at ACTS, the focus ultimately turned to the specific German target sets most vulnerable to attack by heavy bombers. The top three included electrical power, transportation networks, and fuel refining and distribution processes. However, as Peter Faber noted, "Unfortunately—and despite the genuine belief by bomber enthusiasts that the Air Corps had the minimum skills and technology needed to meet...[their]...targeting requirements—the strategic intelligence on which proper targeting depended was still an infant art."²¹ He might have added that as little as was done with targeting, even less was done to develop a tangible BDA

²¹ Peter R. Faber, "Interwar US Army Aviation and the Air Corps Tactical School: Incubators of American Airpower," in Phillip S. Meilinger, ed., *The Paths of Heaven: The Evolution of Airpower Theory* (Maxwell AFB, AL: Air University Press, 1997), 219.

capability. In this sense, the ACTS bombing advocates were lineal descendants of Douhet, who said nothing about assessing the effects and effectiveness of bombing. How a group of officers schooled in the rationalist and scientific tradition of the West could first have posited victory through airpower alone, and in consequence simply ignored the rather fundamental matter of damage assessment, marks one of the few times—and one of the most important—in which both their rationality and their vision proved misguided. In fact, as Faber asserted, it was exactly the obverse of rationality and the scientific method that drove these bombing zealots to develop their new doctrine. Simply put, they placed *too much* faith in technology as an enabler for strategic air warfare, a blind faith that led them to view technology itself—the B-17 and the Norden bombsight—as a panacea that would make bombing a “frictionless” activity sure to succeed. Viewed in this light, it is not so surprising that air intelligence, and especially BDA, received so little attention. After all, if the bomber would always get through, and hit its targets most or all of the time, what real need was there for exhaustive or even cursory BDA? Here was the greatest weakness in the American approach to aerial bombardment.²²

4.4 Doctrinal Development: The British Experience

In contrast to American doctrinal developments in the early interwar period, the British did almost nothing substantive. As Neville Jones emphasized in his work on interwar British bombing doctrine and force structure, Tiverton’s views were put away with all of his files and left to molder in obscurity, a development not coincidental in view of the fact that his doctrinal archrival, Lord Trenchard, became the RAF Chief of Air Staff after World War I and held that position for over a decade. Jones noted that

²² Ibid., 220.

Tiverton's operational-research approach to planning and conducting bombing campaigns simply disappeared in 1919 and that his work was never referred to during either the interwar period or the Second World War. In fact, RAF Bomber Command did not hit on Tiverton's insights until 1941, two years into the war. As a result of this lack of interest in bombing doctrine during the interwar period, the British never developed a clear idea about how best to employ bombers or, for that matter, the bombing and navigation equipment required for accurate bombing.

From 1923 to 1934, with the formation of the Air Ministry Bombing Committee, and in spite of the fact that counter-offensive bomber operations were assumed to be the RAF's most potent capability, nothing was done to turn theory into doctrine, or doctrine into operational reality. In fact, aerial bombardment was no more than a concept during this long decade of British neglect of the air arm. Complacency about the bombing mission and the absence of long-range bombers made Trenchard's ideas about strategic bombing—and any others for that matter—just that: ideas rather than capabilities.²³

This proved troublesome because by the time Trenchard retired in 1929, "the gap between theoretical planning and operational capability, which was already wide, was steadily widening; yet the doctrine of the counteroffensive was preached as fervently as ever."²⁴ In addition, at the moment when the British aircraft industry, including the production of large aircraft, was among the most advanced in the world, the unique opportunity to build a small but nonetheless real heavy bomber force, based on four-engine machines with long range and large payload, simply went a glimmering. As a

²³ Jones, *Beginnings of Strategic Air Power*, xiii, xviii, xx. See also AIR 14/1218, RAF Bomber Command, *Operational Research 1941-44*, which makes no mention of Lord Tiverton.

²⁴ Jones, *Beginnings of Strategic Air Power*, xxi.

result of both Parliamentary and RAF neglect, many aircraft companies went under, and many skilled workers had to look to other forms of employment. The Americans and the Germans came to lead the world in the production of large aircraft and associated instruments and technologies to make flying safer and more efficient, especially at night and in bad weather. The British lagged in all these areas, which would cost their bombing operations dearly in the early years of World War II.²⁵

In addition, Trenchard's preference for bombing cities to undermine an enemy's morale seemed, as noted in Chapter 2, to offer a means of attack by which every bomb could be made to count, and therefore one in which serious BDA capabilities, along with bombsights, navigational equipment, meteorological capabilities, and sophisticated operational techniques, seemed unnecessary. Jones noted that all the work done by Air Staff officers in the final year of the Great War, including Tiverton's, never saw the light of day again in the Air Ministry. "And so," he said,

when the concept of a bomber striking force was revived in the mid-1920s this vital staff work, which should have been the starting point for the development of a peacetime strategic policy, was already irretrievably lost; and during the reconstruction of the bomber force the very existence of the problems which the Air Staff of 1918 had begun to tackle had long since been forgotten.²⁶

The ensuing overconfidence about bombing, despite the absence of any substantive operational capability, reached its most absurd level when Prime Minister Stanley Baldwin asserted in a speech before the House of Commons on 10 November 1932 that "The bomber will always get through."²⁷

²⁵ Ibid., xxii.

²⁶ Ibid., 18.

²⁷ ZHC2, U.K. *Parliamentary Debates* (Commons), 5th Ser., 10 November 1932, Vol. 270, Column 632.

Nonetheless, it would be wrong to say that Trenchard preferred city bombing as nothing more than a vehicle for destroying the enemy's morale. He also believed that Britain's air strategy should be to bring about the systematic disruption of the enemy's war economy and noted that such an air strategy should be based on a precise knowledge of the war industries to be attacked. And here was the rub. No such air intelligence yet existed, and it was not until 1929 that the Committee of Imperial Defence created the machinery for gathering and evaluating information on the German war economy, and not until 1931 that it established the Industrial Intelligence Centre to do this work. In addition, Trenchard's preference for morale bombing was always clear: One of many Air Staff memoranda asserted, for instance, that "the morale of an enemy nation" was "the true object of all war."²⁸ The Air Staff simply held to its twin tenets of bombing doctrine, such as they were: that the bomber would always get through, and that the success of aerial bombardment would be assured by the selection of targets located in urban areas. This conflation of bombing and city attacks was to have serious ramifications for Bomber Command's operations during the Second World War and for the development of BDA. Jones's reminder that the RAF used the same bombsight from 1919 to 1941 is an apt indicator of the degree to which this city-bombing mentality stunted interwar doctrinal and BDA development. So, too, is the fact that the first British four-engine bomber, the Short Stirling Mark III, did not become operational until August 1940, and that four-engine bombers did not appear in large numbers until over a year later. In contrast, by 1937 both the Norden bombsight and the B-17 Flying Fortress were on their way to maturity, and both were operational when the United States entered the war. These were

²⁸ AIR 9/8, Air Staff Memo No. 11, August 1923.

clearly instances in which the rationalism and scientific outlook of the British people, which in most cases held them in good stead, failed abjectly to deal with the core issues surrounding aerial bombardment, namely, doctrine, technologies, and technicians, all of which would have to be developed, belatedly and at great cost, after the war had begun.²⁹

The picture, then, for American and British bombing doctrine, was one of sharp contrast in which the Americans sought more effectively to grapple with the proper role of the bomber as a vehicle for increasing the synergy of joint air-ground operations by attacking both “strategic” and “tactical” targets. They sought the means to produce the greatest effects on the enemy war effort while also maximizing the effectiveness of air-ground operations. Doctrine and training documents made clear the importance of selecting target sets with care, attacking them in a concerted fashion with a maximum bombing effort, and relating those attacks to the larger military effort. These documents made specific reference to the importance of targeting and BDA, both of which were at least present in the American airmen’s ideas about air warfare.

British doctrine, what there was of it, proved utterly inadequate to the task at hand, and the resulting inability to wage effective bombing campaigns for the first three years of the war—and some would argue even after that given Bomber Command’s failure to achieve its stated objective, the defeat of Germany from the air—was disastrous. The implications for targeting and BDA were clear: neither was even remotely adequate, although targeting did receive attention after 1935. As for BDA, there simply wasn’t anything said about it during the early interwar period. The disastrous assumptions that

²⁹AFHRA 512.041-26, Air Ministry, Air Historical Branch 1, *The RAF in the Bombing Offensive against Germany, Vol. 1, Prewar Evolution of Bomber Command, 1917-1939*, 1945; Jones, *Beginnings of Strategic Air Power*, 65.

the bomber would always get through, and that all bombs dropped would have a morale or material effect, and would thus by definition be “effective,” cast their spell over the RAF, Parliament, and the British public. The picture was not quite so bleak, however, for what came to be the key technology associated with BDA: aerial photography.

4.5 Improving Aerial Photography: F. C. V. Laws and George Goddard

The same dynamic as that present in the development of American aerial bombardment doctrine in the early interwar period—one of surprising creativity and deep intellectual engagement in a time of low budgets and civilian disinterest in all things military—was at work in the development of aerial cameras and aircraft in both the British and American air arms. On the surface, developments in these related arenas appeared to have little relation to the later reemergence of a BDA intellectual infrastructure during World War II. For starters, nearly all the emphasis was on mapping and aerial mosaics (both important but not for BDA), and on suitably large and stable platforms to carry the large cameras required for this kind of work. The employment of large and slow aircraft for this work in the period before 1934, and of cameras optimized for taking pictures of very large areas but with relatively little detail, was therefore entirely at odds with the kinds of aircraft that would emerge later to conduct photoreconnaissance for BDA. Air intelligence analysts also fell on hard times during this period, in which the organizational components of the intellectual infrastructure nearly disappeared altogether. However, a core of staff officers, analysts, and photointerpreters from GHQ AEF stayed in the service, as did a number of combat intelligence officers, photointerpreters, and photographic officers from the American bomb squadrons that served in France. These junior officers would provide the

continuity and expertise necessary to see American air intelligence through a far larger conflict—and a far more complex and important air war—two decades later.

Of course, the contextual elements driving developments in aerial photography were, at least on the face of things, driven by the experiences of the Great War and the doctrinal reverberations immediately afterwards. An American Air Service regulation emphasized that artillery relied on aerial photographs to locate its objectives. Even more significant were its references to the role of aerial photographs in providing insights on “the progress of the demolition fire”—in other words, on the effects and effectiveness of friendly artillery fire.³⁰ This employment of artillery damage assessment capabilities, already discussed in greater detail in Chapter 2, had very clear parallels to BDA, and was almost entirely dependent upon photoreconnaissance assets for accurate intelligence. On the technical side, this manual provided detailed mathematical equations for determining area covered for both vertical and oblique photographs, interval of exposures, scale of photographs, and determining the exact location of a point on a photograph, all skills of some significance for photointerpreters during the Second World War. It is also interesting to note that the document, though concerned first and foremost with the role of aerial photography in support of ground armies, nonetheless warned that “The method of photographic reconnaissance which was generally employed during the late war does not adequately exploit the possibilities presented.”³¹ This was, on the face of it, an oblique reference to the requirement for more systematic aerial photography to cover the maximum ground area possible in a given mission in direct support of ground forces.

³⁰ AFHRA 248.262-4, Chief of Air Service, *Manual of Aerial Photography (Provisional)*, Washington, D.C.: General Printing Office, 1920, 5.

³¹ *Ibid.*, 7-8.

However, the explicit reference to the need for large-capacity cameras with a two-thirds overlap of photographs for stereoscopic vision hinted at a recognition that such a capability, which was of the greatest utility in examining complex structures such as factory buildings, oil plants, and other installations with a great deal of focal depth, was one not by any means limited to the direct support of armies.³²

A similar pattern in the development of aerial photography was evident in Great Britain and the United States during this first phase of the interwar period. A number of key individuals, who served as junior officers during the Great War, stayed in the air intelligence business. They pushed forward the same technologies as their American counterparts, focusing especially on cameras and film, and did so within a similar context. Both the United States and Great Britain engaged during this period in a huge program of aerial mapping, the former in the American West, Alaska, and the Philippines, and the latter in the various colonies and Mandates under British rule. During this period, photographic officers, photointerpreters, and combat intelligence officers continued their work at the squadron, group, and wing levels, and they had the additional advantage of working within a larger governmental and military structure that continued to place, if not a high priority on intelligence, then at least a modest one. The most impressive of these individuals, judging by their contributions to the technologies and techniques that later made photoreconnaissance and photointerpretation the most important air intelligence tools of the Second World War, were F. C. V. Laws and George Goddard, who played vital roles in the development of aerial photography during the interwar period, and whom we shall have occasion to discuss in greater detail later.

³² Ibid., 11.

The American focus on aerial photography was significant and sustained during the early interwar period. Just how serious the Americans were can be judged from the publication of a doctrine document in 1924 detailing the proper uses of military aviation, including aerial photography. It noted that of the three key uses for aerial photographs—obtaining information, constructing maps, and aiding effective communication between various military units—obtaining information was the most important. It further asserted that, employed as an information-gathering tool, “The aerial camera is the vigilant and searching eye of the command.” In recognition of aerial photography’s importance as a tool for artillery damage assessment, the document illustrated that photoreconnaissance allowed artillery units to locate their objectives with great precision and ascertain the effects of fire, revealing its progress and effectiveness against enemy defensive works. In addition, enemy dispositions near the front and along distant lines of communication could be studied and the most important headquarters, ammunition dumps, troop concentrations, roads, railroads, and telephone lines located with precision.³³

From there, the document highlighted the emphasis American airmen placed on aerial photography and, by extension, targeting and BDA. “When cities in the rear are to be bombed,” it continued, “a photograph of them aids in picking out the more vulnerable points without the loss of time necessitated by searching for them from the air.”³⁴ This statement was accompanied by a brief reference to Training Regulation 440-190, which described procedures for making aerial photographs, and Training Regulation 210-10, which explained in detail how photointerpreters were to annotate those photographs for

³³ AFHRA 248.262-39, Air Service, “The Military Uses of Aerial Photographs,” 1924, 6-8.

³⁴ *Ibid.*, 11. This was also a reference to the advantages of photoreconnaissance over visual observation.

employment by the G-2 (Director of Intelligence) and G-3 (Director of Operations).³⁵

This emphasis on detailed photointerpretation work by trained air intelligence personnel rested on the assumption that aerial photos were essentially “paper targets” on which photointerpreters could count bomb hits and determine their effects. In this respect—as a tool for gauging the effects and effectiveness of artillery fire and bombing—the aerial photo was an intelligence source of the highest importance and the greatest reliability.³⁶

Although the document focused primarily on artillery damage assessment, the principles involved translated almost exactly to BDA, a fact the authors clearly understood. These involved a recognition that artillery fire was not likely to destroy a target with a single barrage; that re-attack and daily photoreconnaissance to assess the effects and progress of attacks were indispensable; and that stereo-photographs were vital since, given their ability to provide “depth” to photographs, they alone were able to give an exact idea of the process of artillery attacks. There was even a three-tiered damage categorization in which the photointerpreter was required to note changes in the terrain around the object being bombarded and report immediately any information of value derived from analyses of these changes. The three categories and their definitions were:

- (1) A work is completely destroyed when its defensive value is reduced to a line of shell holes that is completely leveled.
- (2) A work is badly damaged when it can no longer perform the function for which it was designed and has thus lost nearly all its defensive value.
- (3) A work which has received several good hits is in no sense demolished, if it continues to perform substantially its defensive or offensive functions. The object of a photographic study is to make a complete and accurate map of the trenches and obstacles totally demolished, those partially demolished and those remaining intact.³⁷

³⁵ Ibid., 13.

³⁶ Ibid., 16.

³⁷ Ibid., 16-17.

These criteria were similar, although not identical, to those employed by several Allied organizations, including the U.S. Strategic Air Forces in Europe, Supreme Headquarters Allied Expeditionary Forces, and the Railway Targets Committee, two decades later in their efforts to describe bomb damage to various targets. For comparative purposes, the abbreviated versions of the Railway Targets Committee criteria are provided here:

- (A) "Damaged to such an extent that no future strategic attacks required.
- (B) Severe damage, but some vital installations intact.
- (C) Attacked, but little or no material damage."³⁸

Despite some differences, the methodologies were similar and the processes for making judgments about the status of each target heavily reliant on photoreconnaissance and photointerpretation. In fact, the document emphasized that "The value of aerial photographs depends directly on the amount of training and experience in their use that is possessed by the persons making use of them."³⁹ One particularly intriguing insight was the importance of aerial photographs for change detection as it applied to *friendly* road traffic. It noted that overhead views of heavily traveled roads could prevent traffic jams and enable traffic dispatchers to utilize roads to the fullest extent.⁴⁰ This same kind of detailed traffic analysis, which in fact was one of the key uses for BDA photographs and reports dealing with an *enemy* transportation infrastructure, would be applied with lethal effect against German rail, barge, and road traffic during the Second World War.

These detailed insights on the uses of aerial photography received further attention in an ACTS lesson plan from 1928, which included four topics: cameras, films, aerial

³⁸ AIR 37/1052, Railway Targets Committee, "Railway Centres: Summary of Operations and Intelligence 9 February to 22 March, 1944." (Summary No. 1), 23 March 1944. There were two other categories in this later effort: (D) Authorized for attack, but not hit; and (E), Scheduled but not yet authorized for attack.

³⁹ AFHRA 248.262-39, Air Service, "The Military Uses of Aerial Photographs," 1924, 30.

⁴⁰ Ibid., 38.

photographs, and employment of aerial photographs. It noted that automatic cameras could carry rolls of film with 75 to 100 exposures each, which produced 7"-by-9.5" prints of excellent quality. In addition, it emphasized that it was possible at that time to deliver finished pictures in ten minutes after exposure since the film could be developed onboard the aircraft, in a miniature darkroom, and the pictures dropped in message tubes.⁴¹

More impressive—and more important for BDA—was a statement that once films and lenses reached a point where they allowed for high-altitude and long-range coverage, and were paired with a high-performance reconnaissance aircraft,

to protect an area or point from aerial photography will require the exclusion of aircraft from areas one hundred to one hundred and fifty miles in width. These points or areas are usually established in the vicinity of some large civil activity, such as a harbor or large industrial area. The exclusion of aircraft from such civil activities will be impracticable. We say that in the future, very few areas can be fully protected from photographic reconnaissance, and it is to be expected that files of all well organized intelligence divisions of major nations will contain photographs of all important points and areas within all possible theaters of operations and lines of communications thereto.⁴²

This prescient statement was followed by a list of the various kinds of targets these aircraft with their advanced cameras would photograph prior to the outbreak of hostilities, including industrial centers containing plants and factories engaged in, or suitable for the manufacture and production of war supplies; key natural resources such as coal and iron mines and oil fields; and transportation facilities, including harbors, docks, marshalling yards, warehouses, and the most vital points in land and water lines of communication, such as bridges, tunnels, dams and canal locks. Detailed knowledge of these targets, the lesson plan said, would allow American ground commanders and

⁴¹ AFHRA 248.262-22, Air Corps Tactical School, "Photography in the Next War," Capt W. W. Wise, 15 May 1928, 1-3.

⁴² Ibid., 6-7.

airmen to determine which of these high-value assets would likely provide the greatest vulnerabilities in a potential enemy's strategy, resources, and power to resist.⁴³

The ACTS faculty built on this lesson plan four years later with the addition of vertical and oblique aerial photographs of major American aircraft factories for instructional purposes and to drive home the value of good photoreconnaissance in targeting and BDA efforts. The most noteworthy thing about these photographs is the process by which they were obtained and the people who obtained them. The ACTS Commandant, Lieutenant Colonel John F. Curry, sent a memo, requesting oblique photos of several factories taken from altitudes between 2,000 and 10,000 feet, and vertical shots showing entire factories, directly to Brigadier General Oscar Westover, Chief of the Army Air Corps. Westover evidently succeeded in convincing several chief executive officers to let the Air Corps photograph their factories, because aerial photographs meeting ACTS specifications arrived on Lt Col Curry's desk, along with a memo signed by the general himself, on 8 August 1932. They included shots of the Martin, Vought, Keystone, Bellanca, Pratt and Whitney, and Wright Aeronautical Corporation factories.⁴⁴

The fact that a clearly offensive conception of aerial bombardment, backed by targeting and BDA capabilities, made it into an approved ACTS lesson plan and was taught to several classes of mid-grade Air Corps officers beginning in 1928, when all references to offensive air warfare were strictly forbidden in war plans and other high-level planning documents, is striking. It indicates the seriousness with which American airmen took these topics, and the professional risks they were willing to take to teach

⁴³ Ibid., 7-8.

⁴⁴ AFHRA 248.264, Memo, Curry to Westover, "Aerial Photographs of Aircraft Factories," 28 March 1932; ACTS Request for Aerial Photographs of Aircraft Factories, 28 Mar 1932; Memo, Westover to Curry, with aerial photographs of aircraft factories attached, 8 August 1932.

them within the larger framework of the evolving high-altitude, precision, daylight bombardment doctrine. Equally interesting was Westover's willingness to ask the chief executive officers for permission to take these photographs given the prevailing climate in Congress, the White House, and among the American public. Whatever professional risks Curry and Westover ran, they were rewarded with excellent aerial photographs to enhance the quality of the ACTS lesson plan.

According to the lesson plan, after commencement of hostilities, bombardment aviation engaged on "strategical missions" against an enemy's war economy would require aerial photographs giving detailed intelligence on those targets. Photographs showing the results of attacks on key lines of communication to delay hostile concentration, the destruction of plants and factories engaged in the supply of war materials, the destruction of supply depots, and the attack of areas where enemy ground units were mobilized and concentrated before moving to the front, would be particularly important. In many ways, this description of future air warfare and its supporting air intelligence capabilities sounded like a dress rehearsal for the transportation and oil offensives in 1944-45. The conceptual framework within which American bombing operated during World War II, and within which its targeting and BDA functions would mature, was clearly well advanced during the early interwar period, not only in doctrine documents and lesson plans, but even more importantly in the cognitive processes of American airmen. One of the most influential of these airmen in the field of aerial photography was George W. Goddard.⁴⁵

⁴⁵ AFHRA 248.262-22, Air Corps Tactical School, "Photography in the Next War," Capt W. W. Wise, 15 May 1928, 9-10.

Like his British counterpart, F. C. V. Laws, George Goddard got his start in the Great War. Goddard had his share of frustrations during the interwar period in his quest to develop increasingly effective aerial cameras and associated technologies. Unlike Laws, however, Goddard worked within an air organization—the Air Service (Air Corps after 1926)—that placed a greater emphasis on aerial photography from the outset. Ironically, the fact that the American air arm was still owned by the Army was very likely the reason for this greater emphasis, given the focus on maps, charts, and photo mosaics for the ground forces. Nonetheless, Goddard, who was one of General Mitchell's protégés, and therefore a believer in the importance of all aspects of airpower, including aerial photography, clearly understood from his earliest days as a military officer that aerial photography might well become an indispensable tool for air warfare as well. It was this focus on what aerial photography might someday do for air warfare that led Goddard and his colleagues in the aerial photography business to develop a number of cameras, new film types, and other technologies at least as good as those developed by the RAF.

Goddard was in the first graduating class of the Aerial Photography School at Cornell University in March 1918. While awaiting overseas assignment, Goddard became an instructor at the school in aerial photointerpretation, where he became intimately familiar with James Bagley's three-lens camera that used film rather than plates, had a greater field of coverage than any other camera then in service, and could accommodate several lenses with different focal lengths. With a viewfinder designed by Goddard, it also provided 60 percent overlap of photos, which allowed for stereoscopic viewing. Along with the K-1 film camera, which joined it near the end of the war, Bagley's camera was the mainstay of American aerial photography during the early

interwar period. The K-1 carried a roll of film 9 inches wide with a 75-picture capacity. Thanks to the efforts of Dr. Kenneth Mees of Eastman Kodak, with whom Goddard developed a close association over the next two decades, this film was the best in the world, providing high-resolution prints ideally suited for photointerpretation.⁴⁶

Goddard took his knowledge of cameras and applied it in France, where he caught Brigadier General Mitchell's attention with his excellent knowledge of photography and its application to air warfare. As the war drew to a close, Mitchell and his chief of aerial photography, Lt Col Edward Steichen, personally ordered Goddard to McCook Field in Dayton, Ohio, where he became Director of Aerial Photographic Research and Development. This was a job perfectly suited to Goddard's talents and belief in the crucial importance of aerial photography. Mitchell and Steichen pushed him hard and provided all the resources a small budget and peacetime environment allowed. In October 1920, Goddard became Photographic Officer, Training and Operations, Air Service Headquarters, Washington, D.C., a position in which he was able to push the art and science of aerial photography forward as fast as a peacetime military, an army jealous of its prerogatives, and a small budget allowed. What he accomplished, here and afterwards, was impressive given these contextual factors.⁴⁷

Goddard oversaw the development of the K-2 camera in 1921, and he convinced the Air Service to purchase an excellent civilian camera, which became the K-3, in 1923. The K-3 had an electric drive, a between-the-lens shutter for sharper images with less distortion, an intervalometer for timed and automatic picture-taking, and a magazine that

⁴⁶ George Goddard and DeWitt S. Copp, *Overview: A Life-Long Adventure in Aerial Photography* (New York: Doubleday and Company, Inc., 1969), 10-11, 24-25.

⁴⁷ *Ibid.*, 20-21, 54.

ensured equal spacing of negatives on the film. In his memoirs, Goddard noted that the K-3, with a number of modifications, was still one of the primary PR cameras in use during the Vietnam War—a service life of over 50 years. Both the K-2 and K-3 were film cameras, with the former carrying enough film to take 100 7x9 inch photographs. A related item of great note—although little recognized at the time—occurred when Sherman Fairchild, who designed the K-3 camera, returned from a visit to Europe in 1923 with an assertion that although the US had the lead in the scientific development of aerial photography, the French and British held the advantage in its practical application. Goddard took note of this assertion and did everything he could to close this gap by advocating more intensive training and larger class sizes at the Air Corps Technical School, which had recently moved from Langley Field in Virginia to Chanute Field in Illinois, but there was relatively little he or anybody else could do with the limited budgets of the early 1920s. This disparity between the British and American application of aerial cameras and photographs to the photoreconnaissance and photointerpretation roles during the Second World War would prove how right Fairchild had been and the degree to which his insight carried forward into the 1930s and 1940s. Of course, the lack of an adequate American photoreconnaissance aircraft played a vital role in this disparity, as did the simple fact that the Americans began developing these processes in earnest, for wartime application, two years after the British. Nonetheless, the disparity became apparent early in the interwar period and persisted until the last years of World War II.⁴⁸

On a more positive note, Goddard related that the fiscal and readiness crises that were constant for the Air Service were much less troublesome for aerial photography.

⁴⁸ Ibid., 66-67, 82, 101.

Once given the planes and the men, our photographic sections had become practically self-supporting. This was so because for every mapping job we did—be it county, state, federal, or military—we charged for our services—gas, oil, repairs, film, chemicals, per diem, the works. What we charged was acceptable because the nature of our work was deemed important and, under some circumstances, received Cabinet and White House approval. Thus while the deterioration of the Air Service was readily apparent, and more and more good men left it, we who were engaged in aerial photography were constantly airborne.⁴⁹

He might also have mentioned that the ability to engage in operational mapping missions constantly, from Alaska to the Philippines, and all across the western United States, gave photographic and photointerpretation officers, and the enlisted men who ran the mobile darkrooms and handled the myriad tasks required to produce high-quality prints from negatives, priceless operational experience that allowed American aerial photography to surge once the United States entered the Second World War. In this respect, the Yanks kept pace with their British counterparts flying similar missions all across the Empire.

While Goddard headed up the Air Service's aerial photography research, development, testing, and evaluation process during the mid-1920s, he realized that his lean budget would not allow him to develop the technologies he felt would be essential during a war in Europe. Goddard thus did what he had done with Sherman Fairchild during the development and acquisition of the K-3 camera: He sought partnerships with civilian companies, the most important of which was the Eastman Kodak Corporation. He visited Dr. Kenneth Mees of Eastman Kodak in 1924 and proposed that Kodak develop a "negapositive" film that would allow for rapid production of prints *without* a requirement to develop them from negatives, function at higher shutter speeds and with higher-speed, fine-grained films, and facilitate the operational employment of a 36-inch

⁴⁹ Ibid., 104.

lens, which required very high-quality film with the characteristics displayed by the “negapositive” film Goddard wanted. Mees agreed to the joint venture and allocated \$5 million to the project, a huge amount by the standards of the day. At the same time, Goddard pushed forward the nascent science of night photography in a cooperative venture with Dr. Sam M. Burka, a physicist and inventor from Johns Hopkins who excelled in optics, chemistry, and navigational equipment. Both of these initiatives paid huge dividends during the Second World War, and they attested to the ease with which officers such as Goddard were able to seek out and employ civilian talent.⁵⁰

This military-civilian cooperation, which occurred throughout the American and British air arms, was particularly close in the air intelligence business. The reasons for this are not entirely clear but had much to do with the fact that air intelligence and all its component parts, including aerial photography, were brand-new endeavors reliant on advanced technologies and techniques, and which consequently attracted junior and mid-grade officers with an interest in their potentialities and a vision of their future roles (it is worth remembering that Goddard was a first lieutenant while he was working on these important projects). Civilian entrepreneurs and scientists saw in them the potential for personal and professional gratification, commercial profit, and the advance of the frontiers of science and technology. All of these motives were clearly at work in the development of “negapositive” film and night photography. They were also examples of Goddard’s recognition, along with many of his fellow airmen, that aerial photography would be a major force multiplier in the next war, not only for ground forces, but also for air forces, a point made clear with the steady development of night photography

⁵⁰ Ibid., 124-126.

capabilities during the interwar period. This was clearly a more purely military application of new photographic technologies and techniques than was involved in aerial mapping, and it thus makes clear that Goddard and others were thinking about combat and assessment capabilities even at the nadir of funding for the Air Service, at a time when the perceived external threat to the United States appeared small indeed, and when mapping held a preeminent position in the aerial photography business.

Goddard's development, in conjunction with Burka, of flash bombs (which necessitated in turn the production of more reliable bomb fuses for predictable detonation timing and altitude), and his work with Westinghouse to develop a photo-electric cell, for placement in the tail of an aircraft, to actuate a camera shutter as soon as it sensed the detonation the flash bomb, underscored all of these deeper realities in the development of American aerial photography. The test of all four of these related technologies (high-speed Kodak negapositive film, flash bombs, new fuses, and the photo-electric cell) over Rochester, on 20 November 1925, was a complete success. Of particular note was Goddard's statement that "Rochester with its rail terminus, industries, and river would make a good military target." Goddard never lost sight of the military imperative for his aerial photography initiatives, and his statement about the suitability of Rochester as a military target hints at a deeper understanding that photoreconnaissance, both day and night, could play a crucial role in targeting, strike photography, and BDA.⁵¹

In 1929, Goddard became Director, School of Photography, Air Corps Technical Command. The school graduated 144 enlisted men a year from a 24-week course that began each month. An officers' course included practical aerial photography, the

⁵¹ Ibid., 147-148.

military use of photographs, photographic interpretation, and aerial intelligence. One of Goddard's first actions as CO was to add night photography to the officers' course. Even in the midst of his duties at the Air Corps Technical School, Goddard made time to push forward his various aerial photography initiatives. One of the more important ones at this juncture was his successful effort, in 1932, to equip a C-8 with a flying darkroom that allowed for rapid in-flight film developing. This capability would ultimately become standard on U.S. Army Air Forces Heavy bombers, all of which had strike cameras installed, allowing for the processing of strike film in flight and the rapid delivery of both negatives and positives to photointerpretation officers at the bombardment squadrons, groups, wings, and numbered air force headquarters (8th and 15th Air Forces).⁵²

One other dream of Goddard's—and one of the few that did not come to fruition until the Cold War—was a dedicated photoreconnaissance aircraft. “A longtime dream of mine,” he said, “had been a plane designed especially for aerial photographic work but because of the money problem I had known it was out of the question.” Goddard might also have mentioned that it was more than a matter of money. There simply was not a high degree of interest in developing a high-performance reconnaissance aircraft capable of holding the newest cameras, which had long lenses and thus required ample room in aircraft fuselages in either the vertical or oblique position. Major Donald Wilson, assigned to the Air Staff and charged with ensuring the best available photographic equipment was in place during future wars, wrote to two of his colleagues, also in the aerial photography business and on the Air Corps Photographic Board, in a fit of frustration, complaining that the brand-new K-9 camera, which could take 9”x 9”

⁵² Ibid., 212, 215-216, 221.

photographs and was fully automatic with remote operation from the cockpit, was also much larger than older cameras and required a larger aircraft for an acceptable fit that would allow for vertical as well as oblique photographs. He bristled at an Observation Board recommendation to the Chief of Air Corps for development of a high-speed, *low-altitude* aircraft, which the Chief approved in 1931 with a directive authorizing development of an aircraft of that type. Wilson stated that AAA and fighters would pose a grave threat to such an aircraft, making a high-altitude version the only safe bet.⁵³

In addition, he attacked the Air Corps decision to make the K-10, a much smaller hand-operated camera, standard issue in observation squadrons. Wilson quite properly criticized the K-10's very limited capabilities as adequate only

for emergency or visual observation missions when it is not practicable to carry anything better...but since we must risk life and property over hostile areas, why use inefficient equipment when the best is available? It is about as sensible an idea as to send out a bomber with a hat full of hand grenades. The K-10...was never intended for routine war missions...⁵⁴

Turning once again to the K-9, he pointed out that even with such an advanced model,

it will be impossible to obtain overlapping photographs from high-speed planes at altitudes as low as say three thousand feet, due to the speed with which the film must be changed between exposures...Furthermore, because of the limited area covered, such photographs would not be satisfactory for interpretation purposes.⁵⁵

Wilson's letter reached a high pitch of exasperation as he lamented that, "In this day and age holes can't be bored here and there in Monocoque fuselages and space can't be found for large cameras if the original construction has failed to provide it." Having seen the

⁵³ AFHRA 248.262-7, Official Memoranda from Major Donald Wilson to Capt George C. McDonald, 10 October 1932, and Capt John M. McDonnell, 2 December 1932, 1-4. Capt McDonald would serve as the Northwest African Allied Air Forces A-2 (Director of Intelligence) and then as the United States Strategic Air Forces in Europe A-2 during the Second World War. He was a major player in the BDA effort and receives a good bit of attention in later chapters.

⁵⁴ Ibid.

⁵⁵ Ibid.

photographic equipment of the world's other major air forces, he believed American cameras and film were by far the best. "And yet," Wilson concluded, "—through some oversight—we are now faced with the possibility of having to scrap some of this superb equipment by adopting airplanes unable to carry it."⁵⁶

Wilson's concerns, and Goddard's, were well-founded. In an inexplicable oversight, America's senior airmen, including Hap Arnold and Carl Spaatz, seem not to have grasped the importance of a high-performance reconnaissance aircraft until they came to recognize the vital role of the Spitfire and Mosquito in the RAF, and by then it was too late. Consequently, they had to rely on converted P-38 fighters (renamed the F-5) in the photoreconnaissance role. These aircraft lacked the combat ceilings of the Spitfire and Mosquito and were therefore vulnerable to German fighters. The results were more failed missions, more aircraft shot down, and more pilots killed. In fact, the 325th Reconnaissance Wing had a higher percentage of its pilots killed than any other Army Air Forces unit in the Second World War, a dubious distinction and the moniker of one of the very few abject failures of vision, technical achievement, and leadership in the interwar and wartime air force.⁵⁷ Fortunately, the same was not true of the British effort to develop high-performance photoreconnaissance aircraft, or of the cameras they

⁵⁶ Ibid.

⁵⁷ Goddard, *Overview*, 216. For the 325th Reconnaissance Wing's loss rate, see AFHRA K239.0512-1024, Interview with Brigadier General Elliott Roosevelt, USAF (Ret), 6 November 1966, 5, 12. Roosevelt commanded the 325th, which included all American strategic reconnaissance squadrons stationed in the United Kingdom. He noted that "We [the 325th Reconnaissance Wing] had a higher loss rate than any other [American] outfit flying in World War II." Although he claimed loss rates as high as 24 percent per month, the 7th Photographic Reconnaissance Group, one of the two groups assigned to the 325th Wing, suffered a 2.6 percent loss rate. See Patricia Fussell Keen, *Eyes of the Eighth: A Story of the 7th Photographic Reconnaissance Group 1942-1945* (Sun City, AZ: Cavu Publishers, 1996), 311-374, which lists every sortie and every aircraft and pilot lost in action. British reconnaissance squadrons, by contrast, had about a 2% monthly loss rate, most of that due to bad weather rather than German fighters, while the majority of American losses were due to enemy fighters. See AFHRA 168.7026-2, Major D. W. Hutchison, Report No. BES-281, "One Week's Visit to the P.R.U. at Benson," 27 October 1941, 1-2, for British loss rates.

ultimately carried, and much of the credit for these successes, both of which proved vital to the development of Allied BDA capabilities during the Second World War, belonged to Goddard's British altar ego, F. C. V. Laws.

F. C. Victor Laws, the "Father of RAF Photography," got his start in photography early in the Great War, when in 1915, as a Sergeant Major, he recommended to his boss, then-Wing Commander Trenchard, commander of First Wing, that the wing's new experimental photographic section be duplicated in all RAF operational wings, and that he be allowed to establish and provide training for each in turn. Trenchard supported Laws's efforts, and as the war continued an increasing number of RFC (later RAF) bomber units received their own photographic sections. Laws's efforts to increase the RFC's aerial photographic capabilities and expand the number of trained photographic officers paid off during a major RFC reorganization in January 1916, resulting in the establishment of two brigades, each with two wings, designed to support the British Expeditionary Force. Each of these wings had its own observation and reconnaissance squadrons. The former was designated a corps-support wing and provided tactical reconnaissance as well as artillery spotting to distance of five miles beyond the front, while the other was designated an army-support wing and conducted strategic photoreconnaissance and bombing operations more than five miles behind the front. Each of these wings had its own photographic section, consisting of one NCO and three enlisted men, all of whom were trained at the School of Photography at Farnborough. Their photointerpretation skills improved rapidly at the front, where at that time they still performed both photographic and photointerpretation duties. (40) This process of increasing the number of photographic personnel and units got into high gear in late

1917, as every bomb squadron by then had one or two aircraft equipped with cameras to provide both strike photographs and either pre-attack or post-strike BDA, and a small photographic section to process and interpret the prints. Laws was intimately involved in all of these organizational developments from 1915 to the end of the war, advocating the importance of aerial photography ceaselessly on the one hand, while pushing forward the practical aspects of the trade, on the other.⁵⁸

Among Laws's greatest contributions in the practical arena was his successful effort, along with several other photographic officers, to develop the L-type and LB-type cameras, which were introduced in 1917 and continued as mainstays in the British aerial photography repertoire until well into the interwar period. The L-type was a breakthrough in that it could be operated either manually or automatically, and could be mounted in any position on the aircraft due to a flexible drive mechanism turned by the airflow over the aircraft. The LB-type employed lenses with much longer focal lengths—up to 20 inches—and were thus capable of taking much more detailed high-resolution photographs, particularly once high-quality bromide paper, film with a smaller emulsion grain of silver molecules, and other advances allowed for a dramatic increase in the sharpness of aerial photographs. These were all crucial prerequisites for BDA as it came to be practiced in World War II.⁵⁹

Laws continued his efforts during the interwar period, despite the fact that the RAF placed little emphasis on aerial photography at this time, a doubly surprising failure given the aerial mapping and air policing missions then being flown by small RAF detachments

⁵⁸ Nesbit, *Eyes of the RAF*, 22, 26, 40.

⁵⁹ *Ibid.*, 42.

all over the globe. Nonetheless, Laws, who commanded the School of Photography at Farnborough three times between the end of the Great War and 1933, continued to push forward the technologies and techniques of aerial photography. One of the most serious problems he had had to deal with in this capacity was the odd fact that the photointerpretation trade, which had remained an army specialty even after the creation of the RAF in April 1918, remained in the hands of the army until 1940. Consequently, army photointerpreters, who focused almost entirely on the creation and interpretation of maps, charts, and photo mosaics for the purposes of planning ground actions and thus lacked the kinds of interpretation skills needed to work in the air intelligence business, were attached to RAF units as photointerpreters. They did have experience with artillery damage assessment, which was in many ways similar to the practice of BDA, but this lack of an RAF training facility specifically for RAF photointerpreters remained a major problem until Laws and several other RAF officers were able to force change in this arena once the Second World War began.⁶⁰

After the end of the Great War, Laws was assigned to the newly-created Directorate of Scientific Research at the Air Ministry, where he was involved in several development projects, one of the most important of which was the F8 camera. Introduced in 1919, it provided automatic overlapping of the ground area covered by successive photographs and 7"x7" prints. These were indispensable prerequisites for stereoscopic photographs (known as "stereo pairs"), which, when viewed using a stereoscope, provided three-dimensional depth, a huge breakthrough for photointerpreters, particularly in the BDA business where the ability to see depth in photos allowed for detailed interpretation and

⁶⁰ Ibid., 54.

the discovery of crucial but minute details. Despite the F8's superior qualities, the Air Ministry considered the camera too heavy and refused to authorize production of more than a handful, a fact the RAF would regret in the first years of World War II, when the F8 finally entered mass production to address a number of aerial photography shortfalls.⁶¹

Similarly, Laws pushed for development of the F24 camera, introduced in 1925, which became the RAF's primary general-purpose camera during the opening years of the Second World War. However, he was disappointed with its limitation to 5"x5" photographs—a fact he brought up with the Royal Aircraft Establishment, which had developed the camera, but to no avail. As Laws knew would be the case, the F24 was ultimately superseded by other types with longer focal lengths that produced larger prints, for high-altitude photoreconnaissance and the detailed photointerpretation reliant on those qualities, but not until after the start of the Second World War.⁶²

Despite his major accomplishments, Laws became frustrated with the lack of concern RAF senior officers showed for the development of aerial photography, and with their rejection of the F8. Very little was being done to develop cameras and aerial photography, and the army was still the only service authorized to train and maintain photointerpreters. Tired of fighting the system, Laws retired in September 1933 to lead a photographic survey in Western Australia, but he returned in 1939, and, as the Air Ministry's Deputy Director of Photography, his influence then would be much greater than it had been either in the Great War or during the interwar period.⁶³

⁶¹ Ibid., 58.

⁶² Ibid., 58, 63.

⁶³ Ibid., 63.

In the meantime, British photointelligence suffered from the vagaries brought on by an impoverished government, public disinterest in martial pursuits, and a near-complete absence of any bombing doctrine or force structure. Ironically, an Air Ministry report produced in 1923 said that "Timely information about the enemy is the foundation upon which all operations of war are planned," and that long-range reconnaissance assets were vital for the provision of aerial photos of enemy industrial activity, shipping and inland water transport, rail construction and movement, road construction and movement, airfields, concentration areas, and supply dumps. Yet little effort was made to develop effective reconnaissance aircraft and cameras. This was odd given the same report's recommendation that a single aircraft capable of flying at very high altitude should have the long-range reconnaissance role.⁶⁴ As Edward Leaf has noted,

the advantages of aerial photography were by and large forgotten between the wars, mainly because, until 1939, the Royal Air Force was confined to the executive role of securing and processing the photographs whilst it was the Army that was responsible for their interpretation and distribution. It was only after the Royal Air Force had been tasked to carry out photographic reconnaissance of Italian possessions in the Mediterranean following the latter's invasion of Abyssinia in 1935 that the Air Ministry recognized that aerial photography in peacetime was one thing and that the system was totally inadequate to cope with the exigencies of war.⁶⁵

In fact, it took six weeks for British policymakers to receive aerial photographs of Italian possessions and military installations in those areas. "By 1938," Leaf continued, the Air Ministry was forced to accept the humiliating fact that the Royal Air Force's ability to execute aerial reconnaissance operations left much to be desired."⁶⁶

⁶⁴ AIR 5/1346, "Training Scheme, Standard Notes, Bomber Squadrons, Necessity for Air Reconnaissance," 1923, 63.

⁶⁵ Edward Leaf, *Above All Unseen: The Royal Air Force's Photographic Reconnaissance Units, 1939-1945* (Sparkford, UK: Patrick Stephens Limited, 1997), 12.

⁶⁶ *Ibid.*

4.6 The Emergence of New Intelligence Agencies

The bitter experience of the Great War, in which the British economic blockade of Germany had failed to bring the government of the Second Reich to the negotiating table, convinced a number of government ministers and members of Parliament that a standing intelligence agency would be required to assess the economic vulnerabilities of Germany and other potential rivals, including Italy. This resulted, in December 1923, in the formation of the Advisory Committee on Trade Questions in Time of War (ATB), which was subordinate to the Committee of Imperial Defense and answered its questions regarding the ways in which other countries' economic vulnerabilities might be translated into military ones. This organization soon began a tentative but increasingly frequent correspondence with another coordinating body, the Industrial Intelligence in Foreign Countries Sub-Committee (FCI), also founded by the Committee of Imperial Defence six years later, in 1929, but this time at the specific behest of the Secretaries of State for War and Air, who sought detailed insights on industrial mobilization in Germany and Italy. To do this effectively, the FCI leadership recognized that an economic intelligence team focused exclusively on these questions was indispensable. Accordingly, they established the Industrial Intelligence Centre (IIC) in 1931. The IIC worked increasingly closely with the Air Ministry's Directorate of Intelligence to determine the vulnerabilities of the German economy to aerial bombardment, a process that developed momentum rapidly once the Nazis came to power in Germany. The obvious connections between economic intelligence and air intelligence, particularly as they related to the vulnerabilities of an enemy's war economy, made themselves increasingly felt throughout the growing British intelligence community in the early 1930s. The natural fit between the two for the

purposes of targeting and BDA was not lost on those involved in early discussions on cooperation and coordination during a future war, and engagement on these key topics gathered momentum despite the “turf battles” and bureaucratic inertia that at times threatened to slow or even derail the process.⁶⁷

Although cooperation between these intelligence organizations in the early interwar period was tentative—it could not have been otherwise given their recent creation—the precedent was set in 1931 and 1932, and this would have dramatic implications for the development of highly effective British air and economic intelligence agencies during the Second World War. The renowned scholar of British intelligence, F. H. Hinsley, emphasized this point at the start of his five-volume study of British wartime intelligence:

In the years before the Second World War several bodies within the British structure of government shared the responsibility for intelligence. They were far from forming a single organization. They had evolved on different lines, within different departments, and no one authority directly supervised them all. Nor could any one authority have done so, given the nature of their responsibilities and the variety of their activities. In some ways, however, they were coming to think of themselves as being parts of a single system for the first time. Perhaps the most significant development of these years is reflected in the fact that they recognized by 1939, as they had not recognized before 1918, the need to strike the right balance between the impracticability of centralization and the dangers and drawbacks of independence and sub-division.⁶⁸

The process by which British intelligence agencies came “to think of themselves as being parts of the same system” proceeded rapidly after 1933 and was a vital chapter in the development of effective wartime BDA capabilities. Equally important was the British willingness to train American intelligence personnel and incorporate them into British organizations while recognizing that the Americans would ultimately seek to set up their

⁶⁷ F. H. Hinsley et al, *British Intelligence*, Vol. 1, 30-32.

⁶⁸ *Ibid.*, 3.

own structures, and actually helping them to do so after 1942. This willingness to accept the Americans as equal partners, and the generous sharing of every kind of air intelligence, including Ultra intercepts, comprised only two of the many outward signs of the effectiveness of British air intelligence. This productive engagement with the Americans, combined with the organizational innovation and cooperation that developed within the British intelligence system, will form the central pillars of this study.

4.7 Bombs, Fuses, and Bombing: Interwar Inertia

There is little to say about the development of bombs and fuses, and about flying training for bomber crews during the early interwar period because little was accomplished in these related arenas. Sir Charles Webster and Noble Frankland, in their history of the British bombing offensive in World War II, summed up the situation nicely by saying of the RAF that "Their stock of bombs largely consisted of those left over from 1918 and hardly anything was done to find out what effects they could produce or whether improvements could be made in their destructive power."⁶⁹ In fact, the prevailing view prior to 1934 was that no bomb heavier than 500 lbs. would be needed in a future war, with exception of a few larger bombs designed to sink battleships. The RAF did develop several new bombs while Trenchard was Chief of the Air Staff (1919-1929), and to his credit Trenchard had recognized the need for very heavy bombs, stating at one meeting in summer 1923 that a bomb as large as 4,000 lb. should be produced. He continued to insist on this requirement, and by 1930 a new 1,000-lb. bomb was in the testing phase, while requirements for 3,000-lb and 4,000-lb bombs were being considered. However, the Air Ministry argument that larger numbers of small bombs

⁶⁹ Webster and Frankland, *Strategic Air Offensive*, Vol. I, 61.

would be more effective than fewer larger ones led Trenchard's successor, Chief of Air Staff Sir John Salmond, to order that no bomb heavier than 500-lbs. be produced, an order in effect until nearly the start of WWII.⁷⁰

There is equally scant evidence of bomb development in the American Air Service and Air Corps during the same period. Part of the problem for both the Americans and the British was the large stockpile of bombs left over from the Great War, most of which were in the 112-lb. to 250-lb. range, but many of which were even smaller. Given the fiscal austerity of the times and the lack of interest in bombing or even outright hostility towards the idea of it, there is no surprise that so little happened with bombs in the period from 1919 to 1934, particularly given the lack of clear enemies during this period.

If the Americans failed to develop improved bombs and fuses, they did much better than the British in their efforts to improve bombing accuracy. A technique known as camera obscura, which included a camera mounted vertically in a bomber, a signaling mechanism on the bomber such as Very lights or a radio, and ground observers, provided important training for aircrews. In short, it taught them to make the best approach to the target and to drop bombs as accurately as possible. When pilots thought they were over the target, their observers or bombardiers would signal the ground. At the same time, the onboard camera would take photographs that could be compared with ground observer reports and photos taken earlier in which the true position of the aircraft over the target was known. This process provided accurate checks on drift and range errors, allowing aircrews to adjust their approach to the target and employ bombsights for maximum

⁷⁰ AIR 2/1267, Minutes of Chief of Air Staff (CAS) Meeting, 19 July 1923; AIR 2/1267, Minute by CAS, 2 August 1928; AIR 2/1015, Minute, DCAS to CAS, 13 December 1930; AIR 2/1015, Decision reached at Air Ministry (AM) conference, 14 October 1932.

accuracy. By comparing photographs, the timing of Very light or radio signals, and ground observer reports, it was possible to determine an aircrew's drift and range errors. The trick was first to train the aircrew to recognize such errors and correct for them and, more importantly, to find a bombsight that could assist by performing these functions. The Norden bombsight was the answer to the latter problem, but camera obscura played its role by forcing aircrews to look for visual cues in the form of landmarks and terrain features along the line of approach, plan carefully their approach to the target, and make the best possible use of existing bombsights, all of which allowed them to overcome the largest navigational errors and improve their bombing accuracy.⁷¹

British efforts to produce well-trained bomber crews, though less effective than those of the United States, nevertheless progressed, if slowly, during the early interwar period. Beyond the question of training aircrews to drop bombs, which occurred infrequently at the RAF bombing range at Orfordness, two important studies based on bombing accuracy during training flights to Orfordness should have gotten the Air Ministry's attention. The first, conducted in 1924, concluded that high-altitude bombing would be impossible on most days over the skies of Europe, while on others it could be carried through effectively by waiting for clouds to clear directly over the target. Similarly, the second study, completed in 1927, asserted that high-altitude bombing under ideal conditions would score hits with no more than 10 percent of bombs dropped on targets less than 200 yards in diameter, and that "very much worse results" were to be expected during periods of poor visibility. It concluded that high-altitude bombing of major railroad and road

⁷¹ AFHRA 168.6005-16, "Camera Obscura," n.d., but written in 1924-25, 1-4.

junctions was “practically useless” given these problems with bombing accuracy.⁷² Due largely to the overarching contextual realities of the early interwar period, these studies fell on deaf ears and were simply filed away. The British would have to learn about the difficulties of high-altitude, precision, daylight bombing, and for that matter night area bombing as well, quite literally on the fly.

4.8 Air Intelligence, Targeting, BDA, and the Drift towards War

The lack of attention to bombs and bombing, especially in Great Britain, began to change once the Nazis came to rule Germany, and it is to the period between 1933 and 1939 that we must now turn to see how the rise of Hitler influenced the development of bombs, fuses, cameras, and other BDA-related technologies, techniques, technicians, and organizational innovations in the British and American air arms. Before we do so, however, it is worth reiterating that the development of bombing doctrine was anything but stagnant during the early interwar period, particularly in view of the larger national and international contexts within which these developments occurred, and its influence on BDA-related ideas and capabilities, particularly on the American side, was significant. American airmen engaged openly and seriously with the closely interwoven questions of aerial bombardment, targeting, and BDA, recognizing that none of the three could stand alone; that, in fact, they only worked in combination with one another. One of the great ironies of the late interwar period, as we shall see shortly, was that the close ties between American doctrine, targeting, and BDA during the early interwar period, which should have resulted in highly-developed targeting and BDA capabilities, did not do so. Equally

⁷² AIR 5/1132, Wing Commander T. R. Cave-Browne, “Methods of Bombing and Their Future Development,” July 1924, 1; and “Summary and Analysis of Some Bombing Results to Date at Orfordness,” 9 October 1937, 6.

surprising is the fact that the British, with their weaker bombing doctrine, equipment, and training between 1933 and 1939, nonetheless surged ahead of the Americans in their development of effective targeting and BDA capabilities. This was due in part to an awareness of the increasing likelihood of war with Germany and Italy, but even more so to a British penchant for organizing their air and economic intelligence organizations and capabilities along the most rational and effective lines.

CHAPTER 5

THE PACE QUICKENS: BDA DEVELOPMENTS IN THE LATE INTERWAR PERIOD, 1933-1941

5.1 British Rearmament and the Bombing Committee

The pace of BDA-related developments quickened noticeably after 1933, although there was as yet no sign of a reemergence of the intellectual infrastructure that had surfaced briefly during the last year of the Great War. The more rapid pace of developments was due largely, but not entirely, to the rise of Adolf Hitler and Nazi Germany, Fascist Italy's aggression in Abyssinia, and the involvement of Germany and Italy in the Spanish Civil War. These concerns drove the British and Americans, slowly, towards an honest appraisal of their bombing capabilities and the actions required for improving them. Because the interwar period ended two years later for the Americans than it did for the British, this chapter reviews developments in the Army Air Corps (renamed the U.S. Army Air Forces in 1941) up to America's entry into the war.

British and American airmen, taking their cue from political leaders, accelerated their efforts to develop effective bombing capabilities. In the American case, this proved less difficult given the firm doctrinal foundations laid during the early interwar period as well as the two superb technologies—the B-17 heavy bomber and Norden bombsight—that emerged during this period. For the British, who had neither a viable bombing doctrine nor an effective bomber force, the process at times appeared as something of a mad

scramble. The war nonetheless caught both the British and the Americans unprepared to engage in bombing operations.

In response to the growing German threat, British air rearmament began in earnest in 1934, but even then 22 of the 41 bomber squadrons called for in the expansion were to be comprised of light bombers incapable of reaching German targets.¹ The primary reason for this move was financial, but it also stemmed from the fact that no satisfactory medium or heavy bomber was even on the drawing board at this point. Part and parcel of this rearmament effort was an Air Ministry decision in January 1934 to establish the Bombing and Air Fighting Committees. The purpose of the Bombing Committee was to “achieve a better measure of coordination between the development of bombing methods and tactics, and the development of equipment required for their efficient application.”² The presence of a representative from Air Ministry R.D.Arm.4 (Analysis of Bombing Results) was noteworthy. So, too, was the *absence* of an air intelligence officer until the committee’s 18th meeting on 26 July 1938.³ This oversight ensured that few discussions of targeting and BDA issues would not occur prior to that time. Nonetheless, several Bombing Committee decisions had implications for the development of a BDA capability and are worth discussing in that context.

At the committee’s second meeting on 30 May 1934, representatives agreed on a need for an automatic bomb sight and formed a Bomb Sub-Committee to ensure proper ordnance would be available in a future war. They reached agreement on the need for six basic bomb types: 18-lb. antipersonnel, 30-lb. and 50-lb. general-purpose, 250-lb. and

¹ Webster and Frankland, *Strategic Air Offensive*, Vol. I, 67.

² AIR 5/1143, “1st Interim Report on the Work of the Bombing and Air Fighting Committees,” September 1936, 1.

³ AIR 5/1141, Minutes, 18th Meeting of Bombing Committee, 26 July 1938, 1-2.

500-lb. high-explosive and incendiary versions, and a 2000-lb. anti-ship bomb. They also agreed on the need for a long-delay fuse. These selections raise a number of questions, the most fundamental of which is whether there was any effort whatsoever to study BDA and MEA reports from the Great War, which were available in Air Ministry files. Had anyone bothered, they would have discovered that small bombs such as the 30-lb. and 50-lb. munitions had been deemed useless for any purpose, and 250-lb. bombs nearly so for attacks on reinforced concrete structures.

The Air Ministry continued to dismiss out of hand the idea that larger bombs would be a requirement in the next war. When Air Chief Marshal Sir Robert Brooke-Popham recommended that the 250-lb. bomb be the standard for the RAF and all smaller munitions discarded, and pushed for development of bombs up to 2,000-lbs. and aircraft with bomb racks capable of carrying them, Air Ministry officers demurred.⁴ Instead, they countered with the assertion that

the result of air action is, to some extent, dependent upon the number of bombs dropped rather than on their size. Furthermore, the chances of hitting a given target are greatly increased by dropping four distributed bombs instead of two...It is thought that the majority of factories, for instance, would be affected to a greater extent by four 120-lb. bombs than by two 250-lb. bombs.⁵

The Air Ministry also dismissed recommendations for 1,000-lb. and 1,500-lb. bombs, saying they would reduce the performance of heavy bombers then on the drawing boards and were thus not worth the effort. Brooke-Popham, Inspector-General of the RAF and one of the very few people who bothered to read Air Ministry files from the Great War, replied that evidence from 1917-18 pointed to the greater effectiveness of large bombs,

⁴ AIR 2/1583, Memo, Brooke-Popham to Air Ministry, 31 January 1935.

⁵ AIR 2/1583, Memo, Air Ministry to Brooke-Popham, 15 April 1935.

noting that engineers designing new bombers had told him they could easily modify the aircraft designs to accommodate large munitions. However, unlike Brooke-Popham, the Bomb Sub-Committee of the Bombing Committee, charged with bomb procurement, neither reviewed existing records of bomb damage during the Great War, nor conducted any bombing tests. Instead, they simply reaffirmed the 1932 decision that no bomb larger than 500-lb. should be produced.⁶ The implications for bombing effects during the first two years of the Second World War were profound.

Equally odd was the committee's lethargic engagement with two issues fundamental to British bombing: an advanced bombsight and a four-engine heavy bomber. The first of these received mention at the twelfth meeting on 6 November 1936, over two and a half years after the formation of the committee, when representatives noted pending delivery of the Mark I automatic bombsight. As it turned out, this model functioned poorly, and as a result no improved bombsight became operational for another *five years*. The second key topic, development of a heavy bomber, surfaced during a number of the committee's meetings and was driven by a realization among senior RAF officers that light bombers had become obsolete. It received further impetus from the "F Scheme" for rearmament proposed by the Committee on Defence Policy and Requirements the same year.⁷ This was a significant expansion scheme because it marked the beginning of Britain's preparations to create a credible bomber force and a recasting of the bomber from a weapon for retaliatory attacks on Germany into one designed to stop a German advance into the Low Countries. This scheme envisioned a major expansion of the

⁶ AIR 2/1015, "Minutes of first meeting of Bomb Sub-committee," 20 May 1935.

⁷ AIR 2/2718, Minute, CAS to DCAS, 29 January 1936.

bomber force, and plans for the Stirling, Halifax, and Manchester were drawn up in 1936-37. The Manchester, although an operational failure with its underpowered engines, was later modified with four Merlins and transformed into the highly-effective Lancaster.⁸

In fact, the "J Scheme" of October 1937 made heavy bombers a top RAF priority for the first time. However, as late as the seventeenth meeting of the Bombing Committee on 4 May 1938, discussions about the "ideal bomber" were still clouded by uncertainty as to what the aircraft's exact capabilities would be and how it was to be employed. In short, there was no doctrinal guidance forthcoming from the Air Staff, and the Bombing Committee lacked the vision to develop one. Consequently, both of these vital initiatives—bombsight and bomber—bore fruit far too late. The bombsight in service with the RAF since 1918 was not replaced by an improved version until 1941, while the first heavy bomber, the Short Stirling Mark III, did not enter operational service in large numbers until the same year. Both the bombsight and the Stirling were abject failures in the length of time required to develop them and in their performance.⁹

As the Nazi threat became clear in 1936 and 1937, the tempo of RAF rearmament increased. In December 1937, the Air Ministry published a document that opened the door to preparation for bombing operations against Germany's economy and morale by ordering Bomber Command to begin detailed planning for a bombing campaign.¹⁰ In consequence, the question of bombing finally received serious attention at the Bombing

⁸ See Colin Sinnott, *The Royal Air Force and Aircraft Design, 1923-1939: Air Staff Operational Requirements* (London: Frank Cass, 2001), 142, 158-59.

⁹ AIR 5/1143, "2nd Interim Report of the Work of the Bombing and Air Fighting Committees," May 1937, 3; "Fourth Interim Report of the Work of the Bombing and Air Fighting Committees," February 1939, 2-3. For insights on the "J Scheme" and heavy bomber developments, see Webster and Frankland, *Strategic Air Offensive*, Vol. I, 74-75. References to the use of the same bombsight from 1918 to 1941 are in AIR 41/39, "Prewar Evolution of Bomber Command 1917-1939; and in Jones, *Beginnings of Strategic Air Power*, 65.

¹⁰ AIR 14/225, Air Ministry to C-in-C Bomber Command, "Air Ministry Directive," 13 Dec 1937, 1-2.

Committee's fourteenth meeting on 5 April 1937, during which representatives discussed problems associated with night bombing, including the idea that target-marking flares dropped by lead aircraft in bomber formations could allow the rest of the formation to bomb an area target with relatively good accuracy. The odd thing about this discussion is that it occurred *before* any serious look at the likely efficacy of day bombing and without any reference to existing reports highlighting the difficulties of precision daylight bombing through the bad weather that Europe experienced during the majority of each year.¹¹ This issue came up at the 19th meeting on 4 October 1938, during which representatives hit on the brilliant revelation that high-altitude bombing was not the ideal method! Low-altitude level bombing, it seemed, worked much better. Of course, no mention was made of the far greater threat from antiaircraft artillery and fighter aircraft at low altitudes. On the whole, therefore, discussions of bombing procedures were disjointed, noncommittal, and incredibly tardy.¹²

Perhaps the only truly successful of Bombing Committee effort, discussed at the 19th meeting on 4 October 1938, had to do with the requirement for a Bomber Development Unit to centralize technical and training initiatives. These had become increasingly disjointed over the previous two decades, with bomb squadrons, training schools, and other facilities engaged in local initiatives unknown to the larger bomber community. The committee had raised this issue previously on three occasions, but the Air Ministry had weighed in against doing anything. Now, finally, the Air Ministry agreed to this

¹¹ AIR 5/1132, Wing Commander T. R. Cave-Browne, "Methods of Bombing and Their Future Development," July 1924; and "Summary and Analysis of Some Bombing Results to Date at Orfordness," 9 October 1937.

¹² AIR 5/1143, "3rd Interim Report of the Work of the Bombing and Air Fighting Committees," March 1938, 1; "Fourth Interim Report of the Work of the Bombing and Air Fighting Committees," February 1939, regarding Bombing Policy Subcommittee meeting of 22 March 1938, 13-14.

initiative. The BDU, as it came to be known, was conceived as a center for the development of bombing doctrine, a welcome change given the absence of doctrinal development during the early interwar period. It was also to be under the operational control of Bomber Command and have a dedicated bombing range for determination of optimum bombing techniques and various types of bombing errors. Night bombing and formation flying were to receive heavy emphasis as well. Operational tests of new equipment and ordnance also figured prominently. Even more important from a targeting and BDA perspective was the decision to place an intelligence officer on the staff to work with bomber crews on target identification and damage assessment during and after practice bombing raids. The creation of the BDU proved to be one of the most important developments in the British bombing effort, one that came to encompass not just bombing tasks strictly defined but also targeting, BDA, and MEA issues relating to the effective employment of heavy bombers.¹³

Equally significant for targeting and BDA was the formation of a Transportation Targets Sub-Committee to discuss the possibility of delaying and disorganizing German mobilization, concentration, and advance during a future war by bombing key railroad viaducts, marshalling yards, embankments, trains, and through lines, in that order of priority. This small body of *ad hoc* targeteers, which included War Office transportation officers and the Superintendent of Railroads as technical advisors, drew up a provisional list of targets based on the first serious nodal analysis of the German transportation network yet performed by British officers. Along with recommending target priorities,

¹³ AIR 5/1143, "Fourth Interim Report of the Work of the Bombing and Air Fighting Committees," February 1939, 5-11.

this group also called for production of a 1,000-lb. bomb for use against transportation targets, a request later approved by the Bombing Committee and the Air Ministry, which ultimately resulted in a very effective wartime weapon. And, in an unprecedented move, they asked the Air Ministry's Director of Intelligence for targeting information and data on German bombs. This may have had something to do with the fact that the Director of Intelligence had finally joined the Bombing Committee as a permanent member and was thus directly involved in the committee's initiatives. At the sub-committee's second meeting on 6 July 1938, members discussed Germany's inland waterways and agreed on the following priority of attack: reservoirs serving canals, canal banks, aqueducts, and lock gates. This, however, marked the end of the road for the sub-committee, which was subsumed by the Bombing Committee. Fortunately, its functions—picking targets and prioritizing them—continued in coordination with the Air Ministry Air Targets Section.¹⁴

In a related development, the Air Staff began working on bombing doctrine, a function it later performed in coordination with the BDU, and determined that two types of targets presented themselves for attack: precise targets and target groups. Attacking the former would require highly skilled bomber crews capable of precision bombardment, while the latter could be struck *en masse* with area attacks on cities and industrial areas. The Air Staff hit upon an interesting solution to this problem that would have significant ramifications for bombing operations, particularly late in the Second World War. They decided to train 25 percent of Bomber Command's crews to high standards for attacks on precise targets, while the rest of the crews would receive training adequate for area

¹⁴ Ibid., 18-19. The Air Targets Section and other organizations with targeting and BDA responsibilities receive a close look later in this chapter.

bombing of target groups. Unfortunately, their idea was to train the elite crews to bomb precise targets from low altitudes, with the assumption (badly flawed as it later turned out) that the crews could effectively under-fly most antiaircraft artillery and fighter aircraft. Ironically, a month later the RAF's Deputy Director of Operations sent a memo to the Deputy Chief of Air Staff proposing the exact opposite course: "Ideal bombing tactics are to bomb from the highest possible height in order to keep out of range of anti-aircraft defences."¹⁵ Accordingly, he proposed bombing tests at 25,000 and 40,000 feet of altitude, the latter with a fully pressurized cabin. Bureaucratic inertia and the lack of a bomber capable of flying at those altitudes doomed the initiative to failure.

Despite the efforts of the Bombing Committee, which unfortunately were neither imaginative nor vigorous, the development of larger bombs, better navigation equipment, installation of cameras on bombers for collection of strike photos, and other BDA-related capabilities were largely ignored until the 1939. Consequently, navigating to and hitting the target received only minor attention, a stunning oversight considering Bomber Command's *raison d'être*. A shortage of money was at the root of some of these problems, but in most cases they resulted from a lack of imagination and judgment about what a heavy bomber campaign would look like. The result would be a disastrous series of daylight bombing raids in 1939 and 1940, a period of urgency in 1940 and 1941 during which new capabilities and tactics were finally developed and deployed, and ultimately a move towards night area bombing as the only survivable means of attacking the Reich.¹⁶

¹⁵ AIR 5/1132, "Air Staff Note on Bombing Policy," 2 February 1938, 2-15; and Memo, DDO to DCAS, 9 March 1938.

¹⁶ Webster and Frankland, *Strategic Air Offensive*, Vol. I, 84, 114-116.

Nonetheless, the air and economic intelligence organizations that developed in the late interwar period and during the first years of the war proved able to support both daylight precision and night area bombing. This was a result of their focus during the late interwar period on developing targeting and BDA capabilities to support a planned daylight bombing campaign against the Reich, and of the subsequent requirement to provide BDA for an entirely different night area bombing effort that matured in 1942. In short, despite the RAF's planning and operational failures between 1934 and 1941, an effective BDA capability nonetheless emerged during the same period, one quite capable of gauging the effects and effectiveness of RAF night bombing and American day bombing operations. This proved to be one of the key British contributions to the Allied war effort because it helped the Allies to win the war faster and with significantly lower casualties than they would otherwise have sustained.

5.2 The First Glimmerings of a New BDA Intellectual Infrastructure

The previous chapter touched briefly on the emergence of three economic intelligence organizations—the Advisory Committee on Trade Questions in Time of War (ATB), its Industrial Intelligence Centre (IIC), and the Industrial Intelligence in Foreign Countries Sub-Committee (FCI)—charged with gathering data on German industries.¹⁷ During the late interwar period, these agencies began to mature and were joined by several air and military intelligence organizations charged with targeting and BDA functions. The increasingly close and productive working relationships between these

¹⁷ The acronym, FCI, comprised the first letters of the last three words in the organization's title. The FCI was subordinate to the IIC, which was in turn subordinate to the ATB. Its role was to gather as much intelligence on foreign industries as possible, particularly for Germany and Italy.

intelligence providers resulted, by the start of World War II, in the first clear indications that a new BDA intellectual infrastructure was emerging.

This process got into high gear on New Year's Day 1936, when the Deputy Chiefs of Staff, who had been appointed by the Chiefs of Staff in 1932 to ensure adequate preparations for war in the event of a conflict with Germany, issued a report favoring the creation of a centralized intelligence structure to facilitate the coordination of intelligence between the various military and civilian intelligence organizations. The report stated that the intelligence business had become immensely complex under the strains imposed by modern warfare, in which the entire human and material resources of the Great Powers were harnessed to the war effort. The problem, they continued, was even more complex in light of the fact that air forces were capable of extending battle zones by hundreds of miles and perhaps to the heart of an adversary's country, including its civilian population and war industries. All of this pointed to the need for closer cooperation between economic and air intelligence agencies.¹⁸

The FCI, comprised of representatives from the Treasury, Foreign Office, Board of Trade, and the Service Ministries, fit this requirement. Its primary functions were to establish direct liaison for exchange of industrial intelligence between the Board of Trade and the Service Ministries, address all issues requiring collective action, and track key developments in Germany and Italy. To support the FCI, the IIC, established in 1931, provided industrial intelligence assessments. By 1934, the FCI had become the focal point for discussion of collection and interpretation of air intelligence relating to targets and target sets of vital importance in Germany and Italy. This organization, and

¹⁸ CAB 54/3, DCOS Memo No. 4, 1 January 1936.

especially its IIC, quickly developed a close working relationship with the Air Ministry and its Director of Intelligence.¹⁹

In their New Year's Day paper, the Deputy Chiefs of Staff stated that an organization should be established to "obtain the maximum effect on an enemy nation, by means of air attack against those objectives the destruction or dislocation of which the government consider would contribute towards the attainment of the national aim."²⁰ They tapped the FCI to do this and recommended that it be responsible for developing air targets intelligence. The Committee of Imperial Defence approved these recommendations on 30 January 1936 and also increased funding for the Service intelligence directorates. The "national aim" the Deputy Chiefs of Staff referred to in their recommendations was not specified, but given recent British experience in the Great War, it was clearly related to the question of bringing Germany or Italy (or both) to the negotiating table by means of a concerted attack on the *economic foundations* of their national power rather than by grappling with their armies. In short, air power was viewed during the late interwar period, at least by some senior civilian and military leaders, as a complement to naval blockade, a substitute for committing another large army to the Continent, and a weapon to hinder a German advance into the Low Countries.

Beyond simply recommending that the FCI be charged with developing air targets intelligence, the Deputy Chiefs of Staff also decided, five months later, to enlarge the functions and manpower of their Joint Intelligence Sub-Committee (JIC), which provided the Chiefs of Staff, Members of Parliament, and the Prime Minister with actionable

¹⁹ Ibid.

²⁰ CAB 54/3, DCOS Memo No. 4, 1 January 1936; CAB 2/6, CID 273rd Meeting, Minute 4, 30 January 1936.

military intelligence. They further directed the JIC, comprised of the chiefs of intelligence from the army, navy, and air force, to work in close cooperation with the Joint Planning Committee, which prepared joint (inter-service) operational plans for the Chiefs of Staff. The Ministry of Economic Warfare, which during World War II would become the focal point for the collection, analysis, and dissemination of all economic intelligence, including BDA reports assessing the effects and effectiveness of Allied bombing of the German and Italian war economies, had not quite arrived, but the flurry of activity in 1936 outlined above heralded its eventual emergence.²¹

The Air Ministry opposed the Deputy Chiefs' idea to establish several targeting sub-committees under the FCI, at least not until the concept proved useful, instead recommending that a single sub-committee be established to study the key targets in and vulnerabilities of the German oil industry—a choice by no means random given the well-known weakness of the German oil position. The Air Ministry followed this with a second memo in which it suggested the FCI act only as an initial point for selection of the most promising targets and, through a sub-committee appointed for the task, assign priorities to targets in various industries. Further, the Air Ministry suggested this FCI Air Targets Sub-Committee, once established, should give the Air Ministry the most detailed available information on German and Italian target sets it thought most important to their war economies and most vulnerable to air attack. Existing reports of the IIC appeared the logical starting point for this process, but they were incomplete and provided few details. The memo closed with a warning: "Much more detailed information is required before any decision by the defence services could be taken regarding the right targets to attack in

²¹ CAB 53/6, COS, 178th Meeting, 30 June 1936.

any given set of circumstances...it is this detailed information which is so vital and without which it will be impossible for right decisions to be taken.”²²

The Air Ministry's requirements, as stated in these memos, were extremely important for the later development of a BDA intellectual infrastructure because they called for the creation of detailed target materials for individual targets within key target sets. This focus on target intelligence had its basis in the fact, all but forgotten by postwar scholars, that RAF senior officers expected to wage a *daylight, precision* bombing campaign against Germany should war come. Once war did come, RAF planners recognized that they had forgotten to address the other, equally important, half of the targeting and BDA cycle, namely, an effective BDA capability. This gave photoreconnaissance and photographic interpretation a huge boost in the war's opening months, and the intellectual infrastructure that grew up as a result ultimately proved equally valuable for gauging the effects and effectiveness of daylight precision *and* night area raids. Still, the initial impetus for development of a BDA capability had its roots in these Air Ministry concerns about target priorities and materials for German war industries.

The Deputy Chiefs of Staff and FCI responded favorably to these Air Ministry concerns with the formation on 26 June 1936 of an FCI Air Targets Sub-Committee (FCIAT) to determine how and where to find the target intelligence required to build detailed target folders for the bombing of Germany. It was chaired by Sir Edward Crowe, Comptroller General of the Department of Overseas Trade. Other members included the deputy directors of intelligence for the army, navy, and air force, and the head of the IIC. The FCIAT was charged with supervising the exchange of information

²² CAB 48/4, FCI 84, 18 March 1936; CAB 48/4, FCI (Sub) 2, 31 Mar 1936.

and reports between the Services and other departments concerned with air targets intelligence in foreign countries. This meant engaging with all likely sources for target materials including the IIC, government departments, businessmen and industrial concerns, industrial research departments, specialists with detailed information on the German economy, British and foreign trade journals, the Special Intelligence Service (MI6), and the Bank of England, which had loaned money to German industrialists for the construction of new factories and held copies of the blueprints for these facilities. This concerted effort to amass targeting information from all available sources marked the point at which air and economic intelligence began a close and fruitful interaction.²³

Inevitably, a dispute arose between the Air Ministry, which had a *de facto* leading role in the FCIAT and sought to push its own target-selection agenda, and the Deputy Chiefs of Staff, who believed that too much Air Ministry influence was not good. The head of the IIC suggested that while the Air Ministry should be given authority to determine numbers of aircraft, weight of bombs, and other technical matters, only the Sub-Committee on Economic Pressure (predecessor of the Ministry of Economic Warfare) should have authority to determine the *effects* of bombing. This was, unbelievably, the first direct reference anyone concerned with target selection had yet made to BDA—in other words, to assessing the effects and effectiveness of bombing.²⁴

In an effort to mollify both sides, the FCIAT proposed that their reports should contain only information on target sets and individual targets therein, which the Air Ministry would review to determine how practical the recommendations were and what

²³ AFHRA 512.041-26, Air Ministry, Air Historical Branch 1, *The R.A.F. in the Bombing Offensive against Germany, Volume I, Prewar Evolution of Bomber Command, 1917-1939*, 1945, 325-327.

²⁴ CAB 55/3, JP 265, 14 June 1939; CAB 48/10, FCIAT 16, 7 August 1937.

their effects on German industry were likely to be. From there, the report would go to the Joint Planning Sub-Committee, which would put it in final form and incorporate it into larger operations plans. Once again, the Air Ministry demurred, countering with a suggestion that the Sub-Committee on Economic Pressure choose vital target systems to be attacked, with an Air Ministry official choosing the actual targets in conjunction with the IIC and the other Service departments. This effectively placed the FCIAT outside the decision loop and made it irrelevant to the target-selection process. In July 1939, as the result of an exchange of memos between FCIAT and Air Ministry, the former was disbanded and the Air Ministry Directorate of Intelligence took upon itself the responsibility for drawing up all industrial intelligence reports and target materials in conjunction with the IIC. For reasons not clear, the Deputy Chiefs of Staff acquiesced and watched the FCIAT, which they had helped create, disappear from the evolving targeting and BDA scene.²⁵

The Air Ministry, having won this bureaucratic turf war, quickly found itself short of manpower, money, and experience to take on the task at hand. The head of the Air Targets Section, which had replaced the FCIAT, complained to the Deputy Director of Intelligence that the Treasury provided too few funds and the Air Ministry too few trained air intelligence specialists to deal with the requirements of this job, especially the extensive and constant study it demanded. It was, he said, "a scientific investigation and study in every sense of the word and the basis of war planning."²⁶ If the FCIAT had proven itself unable to deal effectively as an interface between the military and economic

²⁵ AFHRA 512.041-26, Air Ministry, Air Historical Branch 1, *The R.A.F. in the Bombing Offensive against Germany, Volume I, Prewar Evolution of Bomber Command, 1917-1939*, 1945, 327-328.

²⁶ *Ibid.*, 328.

intelligence agencies, the Air Ministry's struggle to cope with the task made it clear that an effective economic intelligence organization *designed specifically to engage with the service departments*, providing them both economic intelligence for the preparation of target materials and assessments of the economic effects of bombing the German and Italian war economies, was still very much needed. The Ministry of Economic Warfare (MEW) would play this role during the entire course of the war, somewhat tentatively at first, and with a good bit of friction between MEW and the Service intelligence directorates at the outset, but ultimately in a highly effective fashion. Air Ministry officers had the good sense to emphasize that they felt capable of developing detailed target materials based on guidance from MEW as to the most effective target sets to attack, and upon the provision by MEW of detailed economic intelligence. They also agreed, tentatively, that they could probably assess the physical effects of individual bombing raids but not the overall effect of Bomber Command's raids on the German war economy. As it turned out, the Air Ministry proved able to do the things it volunteered to do, including provision of target materials and detailed BDA reports. It provided target materials directly to Bomber Command and later to the USAAF, while the detailed BDA reports came from one of the Air Ministry's most important subordinate organizations, the Central Interpretation Unit (CIU). The CIU, established in early 1940, ultimately employed hundreds of photointerpreters who turned out superb BDA reports and a wide array of other products, including target materials, in conjunction with the Air Ministry.

Although the IIC, the first economic intelligence organization charged with collecting information on the German economy and providing it to all service and governmental agencies, had by all accounts been working well since its formation in

1931, the rapid growth of the intelligence community, and the huge increases in the materials it required, drove an expansion of its duties. By the summer of 1937 the Committee on Imperial Defence recognized the need for an expanded body to make assessments based on economic intelligence provided by the IIC. On 2 July 1937, it formed the Sub-Committee on Economic Pressure, the forerunner of MEW, "To consider the problem of exerting economic pressure on Germany in the event of war with that country in 1939 and to draw up definite plans." By 30 June 1938 this sub-committee was drafting plans for economic warfare against Germany. Its small staff surveyed the scope of economic intelligence still required and recognized that a larger and permanent body, with its director a member of the Cabinet, would be required to provide economic intelligence to the service ministries for war planning. The Committee of Imperial Defence agreed, resulting in the formation of MEW in September 1939, which was initially comprised of 78 analysts. Seventeen came from the IIC, several others from FCI, and the rest from the Sub-Committee on Economic Pressure, all of which were subsumed within MEW. Inexplicably, there was not a single billet for an Air Ministry representative, and the entire focus appeared to be on naval blockade. In fact, the title "Ministry of Economic Warfare" was chosen over "Ministry of Blockade" only because of the legal and ethical complications surrounding the original proposed title. If this exclusion of Air Ministry representatives was brought on by the Committee on Imperial Defence's and the Deputy Chiefs of Staff's perceptions of Air Ministry high-handedness in arrogating to itself the role of air target selection, it was nonetheless a foolish error that would cause serious interagency problems for the first year of MEW's existence.²⁷

²⁷ CAB 47/6, ATB 166 and ATB 167, March 1938; CAB 48/5, FCI 121, August 1938; AFHRA 512.041-26

Despite this exclusion of Air Ministry representatives, the Handbook on Economic Warfare, MEW's doctrine document, did contain a brief section on aerial bombardment as an economic weapon, noting that "air action against economic objectives, if employed at all, can be most effectively employed only if carefully related to the development and effects of other forms of economic warfare." The door was not entirely open to aerial bombardment for economic purposes, nor was it entirely closed. In fact, the handbook stated that the Minister of Economic Warfare would make recommendations on the selection of targets to the Air Ministry.²⁸

The practical effects of these decisions from a targeting and BDA perspective were a requirement for the Air Ministry to collect most of its air targets intelligence solo, with only occasional support from MEW once it became active in September 1939, and a consequent delay in collecting the economic intelligence Bomber Command required to plan its attacks on German war industries. F. H. Hinsley noted that "In the field of economic intelligence inter-departmental co-operation declined, rather than improved, on the outbreak of war."²⁹ It would take another six months before the Chiefs of Staff, MEW, the Air Ministry, and Bomber Command recognized that aerial bombardment had to have a more prominent place in British grand strategy, and that closer cooperation as well as additional manpower resources were needed to make this happen.

The Air Staff Directorate of Intelligence therefore assumed a leading role as supplier of air intelligence to Bomber Command, a role it kept, albeit with increasing MEW assistance and input, for the duration of the war. The first step in this process was to

Air Ministry, Air Historical Branch 1, *The R.A.F. in the Bombing Offensive against Germany, Volume I, Prewar Evolution of Bomber Command, 1917-1939*, 1945, 330-331.

²⁸ CAB 47/6, ATB 197, July 1939.

²⁹ Hinsley et al, *British Intelligence*, Vol. 1, 100.

gather historical evidence of potential utility as Bomber Command developed its air campaign plans. This came from three places: examination of bombing in the Spanish Civil War, experimental evidence on the effects of bombs from peacetime tests, and a careful study of the German war economy. In the first case, there was too little evidence to provide precedents for a future British bombing campaign. The JIC conducted a detailed study of the air war over Spain, concluding that the Iberian Peninsula lacked the industrial base to merit serious study. In addition, the majority of Spain's industry and port cities fell into the hands of Franco's Nationalists early in the war, and his Republican enemies bombed them infrequently. Nationalist air attacks were also restricted mostly to port facilities as each side tried to deny the other arms shipments. Nonetheless, some valuable insights came from this study of bombing during the Spanish Civil War.³⁰

The Nationalist campaign to interdict Republican arms shipments did achieve some success, and available BDA data bore this out. Between 1 July 1936 and 1 November 1938, Nationalist aircraft made 290 raids on Republican ports, most flown by German and Italian bombers. They sank 32 merchant ships and damaged another 128, resulting in a refusal by ships' captains to carry cargoes into Republican ports. The success rate was excellent, with 41.9 percent of anti-ship missions at sea resulting in sinkings or damage, while attacks on ports achieved an 86.6% success rate, with success defined as at least one hit on an element of the port's infrastructure. Cartagena, the only Republican naval repair base, was very heavily damaged by 16 nationalist air attacks, with La Sociedad Española de Construcción Naval in Cartagena stating that, as of August 1938,

³⁰ CAB 54/6, DCOS 100 (JIC), Appendix XVI, 10 June 1939; CAB 54/6, DCOS 102 (JIC), 10 June 1939.

the works as a whole have been very seriously damaged, and parts of them completely destroyed. Such machinery as may still be serviceable is being removed to a foundry on the outskirts of the town. The...offices are burnt to the ground...and a full set of turbines was ruined.³¹

Barcelona and Valencia also received steady and at times heavy air attacks. In August, 1938, the British Consul at Valencia stated that

The recent air raids have wrought chaos in the harbour. Only about one hundred and twenty-five yards of quay space remain available to shipping. Warehouses, the weigh bridge and sidings are smashed by bombs. The wreck of two ships, the harbour dredger, and two sailing vessels obstruct the approach to the wharves. One small crane, useless in its present position, alone remains of the lifting appliances.³²

Nationalist bombers dropped 20-kilogram (44-lb.) incendiaries, and 100-kilogram and 250-kilogram (220-lb. and 550-lb.) high-explosive bombs. The larger bombs proved highly effective against unarmored merchant ships, while a combination of incendiary and high-explosive bombs produced significant blast and fire damage in Cartagena. The high success rates enjoyed by Nationalist bomber crews (who were relatively well trained Germans and Italians) had much to do with the fact that they were able to deliver their weapons from low altitude as a result of the weak anti-aircraft defenses aboard Republican ships and in their ports, but the results pointed to the utility of bombing ships at sea and port facilities in conjunction with a naval blockade.³³

If the direct results of Nationalist bombing appeared promising, the indirect effects (now known as "cascading," or second-order and third-order effects) proved harder to demonstrate. These included the potential effects of bombing port facilities to restrict arms imports (a second-order effect) and thus to reduce the combat power of Republican

³¹ CAB 54/6, DCOS 100 (JIC), Appendix VIII, 10 June 1939.

³² Ibid.

³³ Ibid.

armies (a third-order effect). The JIC considered these effects more important than the physical damage inflicted by Nationalist raids but also quite difficult to determine with any precision. Imports of all kinds, including arms, to Republican-controlled Spain declined during the first half of 1937 and stayed below pre-war levels at the ports in question, which was largely the result of a 390 percent increase in freight and insurance premiums placed by British insurers on sailings to Spain. In this sense, the indirect effects of bombing appear to have been real, if somewhat modest. Nonetheless, the British Consul at Valencia stated that despite heavy damage to shipping and port facilities, the Republicans received adequate arms and ammunition. He concluded that the Nationalist air offensive, which waxed and waned with varying intensity and with relatively few raids by small groups of aircraft, was an "excellent example of how not to utilize a complete mastery of the air." More frequent and larger raids were needed, he said, if severe and lasting damage was to be done to the Republican war effort.

Transportation attacks against the Republicans were even less effective, again due to the relatively undeveloped Spanish rail and road infrastructure. The two areas of Nationalist focus were the railroad leading into northeastern Spain from France, and railroads leading from major Republican ports towards the front lines. These attacks proved ineffective because there were alternate delivery routes, the Spanish railways were operating well under maximum capacity, and the weight and frequency of attack were far too small to offer any real hope of success.³⁴

The Air Ministry and Bomber Command drew several conclusions from the Spanish experience, the most important of which was that the air war over Spain was not large or

³⁴ CAB 54/6, DCOS 100 (JIC), Appendix XVI, 10 June 1939; CAB 54/6, DCOS 103 (JIC), 10 June 1939.

important enough to have had a serious effect on the course of hostilities. This by no means meant that aerial bombardment of an enemy's war industry had no potential, but rather that airpower, used in small packages, for infrequent raids on underutilized economic and transportation infrastructures, would not have decisive effects. The only notable BDA reports to contradict this view came from Cartagena and Valencia, but they were exceptions to the rule. The two major lessons the British drew from the Spanish Civil War were that air attacks would have to be much larger, and that they would have to be more frequent and concentrated against a few key targets within a given target set.³⁵

The Air Ministry's second line of approach was to study the evidence available from bombing trials, and to draw from it suppositions about the likely effects of bombing German industries. The key problem here was the fact that bombing trials in the United Kingdom were neither frequent nor comprehensive enough to offer conclusive insights. Also problematic, and inexplicable, was the Air Ministry's failure to consult BDA and MEA records amassed during the Great War and the bombing survey that followed. In September, 1938, Air Chief Marshal Sir Edgar Ludlow-Hewitt, Commander-in-Chief of Bomber Command, stated that without exhaustive bombing trials, "we cannot hope to devise our bombing tactics on sound and practical lines unless we have the facilities to explore every branch of the subject [in other words, MEA] by means of practical trials..."³⁶ His plea went largely unheeded, and the bombing trials largely unfunded.

³⁵ CAB 54/6, DCOS 100 (JIC), 10 June 1939. Ironically, the British forgot these lessons during their first bombing campaigns in 1939-40, dispersing their bombers in numerous attack packages as small as one or two aircraft.

³⁶ Air Ministry File S. 36637/II, Enclosure 1a, September 1938, quoted in AFHRA 512.041-26, Air Ministry, Air Historical Branch, *The R.A.F. in the Bombing Offensive against Germany, Volume I, Prewar Evolution of Bomber Command, 1917-1939*, 1945), 340.

There were a few bombing trials at Netheravon in 1938-39 to determine the effects of high-explosive and incendiary bombs on aircraft dispersed at an airfield; at Longmoor, to determine the effects of high-explosive bombs on railroad lines and embankments; and at Portland, where a simulated attack on the Home Fleet and its shore establishments was made. An RAF Historical Section Report noted that the bombing trials were designed not only to determine weapons effects, but more importantly to “assess the damage that could be inflicted in war...” In other words, the development of BDA capabilities was finally on the RAF’s collective mind and an issue singled out for emphasis during these bombing trials. The British used 250-lb. and 500-lb. bombs, most of which either missed their targets or did damage that could be rapidly repaired by capable repair crews. Difficulties in finding and approaching targets, crude bombsights, and the limited number of targets attacked during these trials all underscored the long road ahead for Bomber Command in its effort to develop a potent bombing capability.³⁷

The final category of information sought by the Air Ministry on the potential effects and effectiveness of bombing came from their efforts to study German industrial target sets and then select the most promising for targeting and operations-planning purposes. This effort was intended to build on and refine the Air Ministry’s 1 October 1937 document containing 13 Western Air Plans, including three for Bomber Command: W. A. 1 (attacks on German Air Striking Force, its maintenance, and the aircraft industry); W. A. 2 (attacks on German rail, canal, and road communications during concentration of German armies in the West and to delay their invasion of France and the Low Countries);

³⁷ AFHRA 512.041-26, Air Ministry, Air Historical Branch 1, *The R.A.F. in the Bombing Offensive against Germany, Volume I, Prewar Evolution of Bomber Command, 1917-1939*, 1945, 341, 344.

and W. A. 5 (attacks on German manufacturing centers inside and outside of the Ruhr and on inland waterways).³⁸ These plans had been developed in response to a May 1937 directive from the Committee of Imperial Defence to the Services to develop war plans. On 24 July 1939, the Air Ministry Directorate of Intelligence put forth a study, based on available industrial intelligence, which approached the problem from three directions. The first was an attack on vital industries, including chemicals and explosives, synthetic oil plants, metallurgical industries, and foodstuffs.³⁹ Air Ministry Intelligence argued for attacks on these target sets to inflict the maximum economic, military, and morale effects. This was a serious problem given that even those targets closest to Great Britain, most of which were in the Ruhr, lay at the extreme limits of medium bomber range and were beyond fighter escort range. Also, there were only 488 medium and light bombers in service in September 1939.⁴⁰ The need to develop a bomber force with the range, payload, navigational instruments, and defensive armament to reach these targets was ignored for the moment.

The second approach was to focus exclusively on fuel and power as the two motive forces behind the German war economy and armies in the field. Already at this point, air intelligence personnel and their counterparts at ATB (later MEW) agreed that Germany's greatest weakness was in her tenuous oil supplies. With this in mind, the study focused first on liquid fuels (aviation fuel and gasoline), then on solid fuels (coal), and finally on

³⁸ AIR 2/2731, Air Ministry conference, 1 October 1937.

³⁹ The study was based on a series of detailed Air Ministry evaluations of these major German target systems. Detailed appendices listed the individual targets for each system, provided maps for each target, and assessed each target's vulnerability to attack. For further insights, see AIR 9/89, Air Ministry, Air (Targets) Intelligence, Germany, reports, 28 April 1938 to 14 June 1938.

⁴⁰ R. J. Overy, "Strategic Bombardment before 1939: Doctrine, Planning, and Operations," in R. Cargill Hall, ed., *Case Studies in Strategic Bombardment* (Washington, D.C.: Air Force History and Museums Program, 1998), 67.

coal-fired and hydroelectric power plants. In the latter case, the study also touched on the major German dams that allowed for the country's relatively high use of hydroelectric power. The study then made the case for simultaneous attacks on power supplies and the transportation infrastructure required to move the raw materials underpinning them, with the latter including major railways and marshalling yards, major rail and road bridges, and inland waterways.⁴¹

The third option was to attack one area—the Ruhr industrial district—intensively with the idea of causing enough economic pain to bring German leaders to their senses or to force the Luftwaffe to defend its own territory rather than attempting a “knock-out blow” against London. Ludlow-Hewitt favored Plan W. A. 5 with an emphasis on the electric power system.⁴² However, the Air Targets Intelligence Committee disagreed and instead pushed for attacks on transportation targets, particularly dams and inland waterways. These included the Eder, Mohne, and Sorpe dams; the Dortmund-Ems and Mittelland canals; and fuel and power supplies to paralyze war production in this vital German economic region. Daylight precision attacks were planned to destroy key industries, with night attacks to lower morale and productivity as a result of area bombing and constant air raids. Their vision became reality during the Bomber Command attacks on the Ruhr in 1943-45 in conjunction with the transportation offensive against the Reich, one of whose aims was to isolate the Ruhr from the rest of Germany. Of course, in 1944 the RAF and the USAAF had well over 4,000 heavy bombers in operation against

⁴¹ CAB 47/16, ATB 181, 22 July 1938, Appendix I (revised 24 May 1939); AIR 9/89, Air Ministry, Air (Targets) Intelligence, Germany, reports, 28 April 1938 to 14 June 1938.

⁴² AIR 2/2805, Memo, Ludlow-Hewitt to Air Ministry, 20 Jul 1938; AIR 14/225, Memo, Ludlow-Hewitt to Secretary of State for Air, 30 August 1938; AIR 2/2805, Air Targets Intelligence Report on Transportation, 9 September 1938.

Germany, and, just as important, the photoreconnaissance and photointerpretation capabilities necessary to gauge accurately the damage wrought by these attacks. In the summer of 1939, when these plans were first laid down, the British had a few hundred two-engine bombers and little of the BDA intellectual infrastructure in place.

Nonetheless, this plan to attack the Ruhr, when viewed in combination with the other two options—attacks on key industrial target sets, and attacks on vital energy sources and transportation networks—presaged in large part the Allied bombing strategy put in place during the final two years of the war. At the time, however, the British planners opted for the Ruhr as being the most vulnerable of the targets put forth in the three Directorate of Intelligence reports.⁴³ Ludlow-Hewitt and a number of other senior officers realized, however, that even if the British developed heavy bombers capable of striking hard at these targets, they would need photoreconnaissance machines capable of collecting targeting and BDA data to guide the planning and execution of bombing campaigns.

Beginning in September 1937, the Air Ministry sent a series of memos to all its Air Officers Commanding-in-Charge of bomb wings, groups, and squadrons regarding the importance of aerial photography as an aid to judging the effects of bombing operations. Ludlow-Hewitt replied in two memos, dated 23 November 1937 and 7 January 1938, noting that it was “most evident” to him and his staff that photoreconnaissance would prove “exceedingly valuable” in obtaining “the required information of the results of raids, and of enemy activities, so as to enable Bomber Command to direct operations.”⁴⁴

⁴³ AFHRA 512.041-26, Air Ministry, Air Historical Branch 1, *The R.A.F. in the Bombing Offensive against Germany, Volume I, Prewar Evolution of Bomber Command, 1917-1939*, 1945, 353-354.

⁴⁴ These are located in AIR 2/2683 and AIR 2/2813. In particular, see A.M. File S.42910, 22 September 1937, Enclosures 1a, 11a, and 20a, for Air Ministry guidance and Ludlow-Hewitt's statements.

Finally, he expressed the opinion that special reconnaissance aircraft—lightly armed and equipped to provide for high speed—should be part of Bomber Command's equipment:

So long...as we have to depend only upon the heavy bombing missions to obtain our information and photographs we cannot expect the best results, which will only be obtainable when we have aircraft suited for special reconnaissance missions...⁴⁵

These memos represented the first clear effort to grapple with the technical and operational issues surrounding the development of a real photoreconnaissance capability.

Ludlow-Hewitt also advocated pre-takeoff briefings to provide detailed target information, pushing for the addition of full-time intelligence officers to every bomb squadron for this purpose. He recommended that the results of every bombing mission be checked by either photoreconnaissance aircraft or cameras onboard the bombers. (The fact that his bombers had no such cameras was a shortcoming Ludlow-Hewitt raised repeatedly with the Air Ministry.) He also pressed the Air Ministry to give his intelligence officers detailed target materials to assist with mission planning and damage assessment, train photointerpreters to provide BDA reports based on the photographs taken by reconnaissance aircraft, and station those officers at the Air Ministry, HQ Bomber Command, and bomber units to obtain BDA reports without delay.⁴⁶

Ludlow-Hewitt's statements are noteworthy because they comprised the first clear statement *by an operational commander* that photoreconnaissance would play a vital role in the impending war. His comments also exposed the most glaring manpower deficiency in the RAF: an almost utter absence of trained photointerpreters to provide damage assessments for Bomber Command attacks. Fortunately, Ludlow-Hewitt's

⁴⁵ AIR 14/298, Bomber Command Annual Report for 1938, 11 March 1939.

⁴⁶ Jones, *Beginnings of Strategic Air Power*, 136, 141; AFHRA 512.041-26, Air Ministry, Air Historical Branch1, *The R.A.F. in the Bombing Offensive against Germany, Volume I, Prewar Evolution of Bomber Command, 1917-1939*, 1945, 355.

comments lit a fire under the Air Ministry, which issued a memo entitled "Photographic tasks for which the Squadrons of the Royal Air Force are to be trained." It levied a requirement on flying units and HQ Bomber Command to have trained officers for identification and location of bombing objectives, production of target photographs for examination by aircrews, recording bombing results, and producing BDA reports.⁴⁷

5.3 Aircraft and Cameras: On the Threshold of Revolutionary Change

The Air Ministry began major efforts to develop photoreconnaissance capabilities in 1936. Given the limited time remaining before the start of the war, few new or capabilities were in place by September 1939. However, efforts begun in 1936 laid the groundwork for many successes to follow. By March 1938, the Air Ministry had responded to Ludlow-Hewitt's calls for specialized reconnaissance aircraft, cameras to be mounted in bombers for obtaining strike photographs, and the training of photointerpreters to study aerial photographs for the purposes of targeting and BDA. The Air Ministry realized the first step in this process, which was focused on aerial bombardment, would be to obtain aerial photographs of key German targets.⁴⁸

This question of photoreconnaissance ran into two problems: signed agreements between Great Britain and Germany preventing aerial reconnaissance of one another's territory, and the lack of a reconnaissance aircraft capable of flying covert, long-distance missions over Germany. The Air Ministry's answer to these problems was to defer to the Special Intelligence Service (MI6), which was charged with acquiring intelligence by means of espionage. To do this job, Wing Commander F. W. Winterbotham, commander

⁴⁷ See AIR 2/2683 and AIR 2/2813. In particular, see A.M. File S.42910, 22 September 1937, Enclosure 23a, for Air Ministry guidance

⁴⁸ AIR 41/6, Air Ministry, *Photographic Reconnaissance*, Part I, 5.

of SIS Air Section, established a new unit, SIS Flight, in November 1938. To lead it, he hired an enterprising Australian named Sidney Cotton, whose work would have a major influence on the development of photoreconnaissance and photointerpretation in the RAF, and, by extension, the emergence of an effective BDA capability. Although he will receive much more attention in the next chapter, it is enough for now to note that Cotton, a Royal Naval Air Service flying officer from the Great War and a highly successful pilot and entrepreneur, agreed in the fall of 1938 to set up a front company, the Aeronautical Research and Sales Corporation. Winterbotham and Cotton, working with the French *Deuxieme Bureau de l'Armee de l'Air*, purchased four Lockheed 12A aircraft, two each for the French and British, which provided superb service from April to September 1939.

Cotton then set up shop as a respectable aircraft salesman in an office in France, and in March 1939 set about flying clandestine photoreconnaissance missions over Germany as he traveled to and from meetings with various German aircraft executives. Cotton's choice of the Lockheed 12A, and of the high-quality cameras and lenses he placed in both the fuselage and wings, were based on his realization that photoreconnaissance, whether clandestine or overt, required high-altitude, high-speed, long-range, and low-observable aircraft with fully automated cameras. He painted his aircraft a pale, duck-egg green to make them virtually invisible to the naked eye and installed extra fuel tanks, extending their range from 700 to 1,600 nautical miles. During spring and summer 1939, Cotton and his co-pilots made seven flights across Germany, returning each time with a huge number of excellent photographs of industrial facilities, oil plants and refineries, airfields, ports, and other key targets. Cotton had installed three cameras in the fuselage of his Lockheed 12A, one set vertically and the other two at a 40° angle, which allowed him to

photograph a strip of ground 11 miles wide and dozens of miles long, from a flying altitude of 22,000 feet. He also discovered that warm air flowing from the fuselage outward over the camera lenses kept them clear of ice while also keeping the mechanical actions from freezing up. This same effect was later created by venting engine exhaust over cameras in the Spitfire and Mosquito. The quantity and quality of photographs provided dwarfed anything the RAF had ever been able to manage with its Blenheim and Lysander reconnaissance aircraft.⁴⁹

In August 1939, one of Cotton's co-pilots, Flying Officer Maurice "Shorty" Longbottom, sent a crucial memorandum to the Air Ministry. Longbottom, short in stature but long on courage and insight, made the case for improving the RAF's photoreconnaissance capability with the addition of a dedicated high-performance aircraft. "The best method" for doing this, he said,

appears to be the use of a single small machine, relying on its speed, climb, and ceiling to avoid destruction. A machine such as a single-seater fighter could fly high enough to be well above Ack-Ack fire and could rely upon sheer speed and height to get away from the enemy fighters. It would have no use for armament or radio and these could be removed to provide room for extra fuel, in order to get the necessary range. It would be a very small machine painted so as to reduce its visibility against the sky.⁵⁰

Longbottom had worked through this problem with Cotton and Flying Officer Robert Niven, Cotton's other co-pilot, during the preceding year, and the memo, though signed by Longbottom, was clearly a product of this collaborative effort. The adoption three months later of a specially modified Supermarine Spitfire as the RAF's primary photoreconnaissance platform, within a flying unit soon to be known as the Photographic

⁴⁹ Hinsley et al, *British Intelligence*, Vol. 1, 28-29; Leaf, *Above All Unseen*, 13-16.

⁵⁰ AIR 41/6, Air Ministry, *Photographic Reconnaissance*, Appendix XII.

Reconnaissance Unit (PRU), revolutionized the RAF's photoreconnaissance capabilities and paid huge dividends for the Allied war effort. The PRU had its genesis in the decision by Air Vice-Marshal R. H. Peck, the Air Ministry's Deputy Director of Operations, to take Cotton's SIS Flight into the RAF once the war began.

Just as important as Cotton's and Longbottom's ideas about photoreconnaissance, was Cotton's recognition that a new kind of photointerpretation capability would be required to maximize the value of the high-resolution aerial photographs that would soon begin pouring into British intelligence agencies. Cotton argued for an organization with a *centralized photo processing and readout capability, specialized photo interpretation by target categories, and a centralized reconnaissance collection management function* to satisfy all requests from military and civilian intelligence organizations. These capabilities were all to become hallmarks of the Photographic Intelligence Unit (PIU), later renamed the Central Interpretation Unit (CIU).

These two intertwined assets—the aerial photographs provided by the Spitfires of the PRU and the photointerpretation expertise provided by officers at the CIU—emerged in early 1940. In combination with the maturation of air and economic intelligence organizations, including the Air Ministry and MEW, they marked the reemergence of an intellectual infrastructure orders of magnitude greater than its predecessor in the Great War. In the eyes of a recognized expert, Cotton's accomplishments thus made him “unquestionably the father of World War II Allied photoreconnaissance.”⁵¹

In the meantime, however, there was much work to do. The RAF's Blenheim and Lysander reconnaissance aircraft were woefully inadequate and very vulnerable to

⁵¹ Stanley, *World War II Photo Intelligence*, 40.

German fighters, and the Air Ministry had a grand total of *one* trained photointerpreter, Squadron Leader Walter Heath, to interpret the Cotton organization's aerial photographs. Equally problematic was the practice of requiring intelligence officers stationed at bomber units to interpret strike photos *without* formal training. As increasing numbers of bombers were equipped with cameras to produce these photos, the need to give unit intelligence officers interpretation training became evident. The principal reason for the shortage of trained RAF interpreters was the practice during the interwar period of training only army officers and attaching them to RAF units when requested. Thus, although the RAF School of Interpretation at Farnborough opened in 1922, the army provided all its instructors and pupils until 1938! Once the Air Ministry saw the need for additional photointerpreters in March 1938, and founded a section, A.I.1(h), to address this requirement, additional RAF officers received training at Farnborough. By 1 September 1939, there were six trained officers at HQ Bomber Command. In addition, a few intelligence officers assigned to bomber units received this training before the war, and many more after it began.⁵²

Several other developments related to aircraft and cameras were promising at the time and are worth noting here. Harry Stringer, the foremost British authority on aerial cameras, and one of the original pioneers in the field along with F. C. V. Laws, had already started experimenting with camera mountings in the fuselage and wings of a crashed Spitfire when Cotton approached him in the fall of 1939 to ask for assistance outfitting his first two Spitfires with cameras. Stringer did so, and as a result the first

⁵² Babington Smith, *Evidence in Camera*, 8; Powys-Lybbe, *The Eye of Intelligence*, 20; Hinsley et al, *British Intelligence*, Vol. 1, 29.

operational photoreconnaissance Spitfire sortie occurred on 18 November 1939. Cotton also approached Mr. H. Hemming, head of the Aircraft Operating Company, to ask for assistance with interpretation of the aerial photographs starting to arrive from reconnaissance sorties. Hemming agreed to loan Cotton his photogrammetric expert, Michael Spender, and the Swiss-made "Wild" photogrammetric machine, which allowed for precise measurements of objects in aerial photographs and marked a huge advance in photointerpretation capabilities. The Aircraft Operating Company and its employees would soon be drafted by the RAF as the core of the PIU and thus of the CIU.⁵³

5.4 Bombing, Bombs, and Navigation: Continued Stagnation

If the reconnaissance and photointerpretation pieces of the intellectual infrastructure were starting to emerge by the fall of 1939, bombs and bombing techniques still lagged. Despite the increasing likelihood that British bomber crews would soon be ordered into action against the Reich, they continued to drop practice bombs during clear weather, at low altitudes, on familiar ranges, and against familiar mock targets. Because the crews knew their way to and from the practice ranges, and flew only during daylight hours, no navigational improvements of any note occurred during this period. These practice drops flew in the face of Air Ministry guidance in the Manual of Air Tactics for 1937, which stated that daylight, *high-altitude* bombing would be the norm. Henry Tizard, who since 1936 had headed the Committee for the Scientific Survey of Air Offence, which was formed and instructed "to consider how far recent advances in scientific and technical knowledge can be used to strengthen present methods of offence in the Royal Air Force," was concerned with the RAF's lack of interest in navigation, especially at night. He

⁵³ Babington Smith, *Evidence in Camera*, 22-24.

observed, in November 1938, that "relatively too much work has been put into what you do when you find the target and too little on the actual finding of the target."⁵⁴ Tizard and his committee failed to drive any major improvements in this arena before the war, mostly because of resistance they received, ironically, from Bomber Command officers.

The absence of realistic bombing practice, combined with infrequent training missions, meant the bombing data essential for understanding the effects of various bombs on different targets did not exist prior to the war. Attacks thus had to be planned with only a vague idea of the damage they would cause. Group Captain J. C. Slessor noted in October 1938 that the RAF was "neglecting practical research and experiments bearing on the relative vulnerability to air bombardment of various kinds of targets and on the types of bombs and tactics, which will bring about the destruction with the least expenditure of effort of each type of target."⁵⁵

The irony of this situation is palpable even today: It was the British BDA capability that exposed the dramatic operational shortcomings of British bomber crews, bombs, and bombsights in 1939-41. The irony must have been bitter indeed when the same BDA capability later confirmed that American aircrews bombed very accurately under the right conditions. Here we are reminded again of the odd but serendipitous relationship between British "precision BDA" and American "precision bombardment." What should not be lost on us here is that British BDA reports would have portentous effects on the course, conduct, and effectiveness of Allied bombing throughout the war.

⁵⁴ AIR 2/2730, Air Staff Paper, 7 January 1937; AIR 20/17, Minutes of Air Offensive Committee, 4 May 1937; AFHRA 512.041-26, Air Ministry, Air Historical Branch 1, *The RAF in the Bombing Offensive against Germany, Vol. 1, Prewar Evolution of Bomber Command, 1917-1939*, 1945, 167; Webster and Frankland, *Strategic Air Offensive*, Vol. 1, 114.

⁵⁵ Jones, *Beginnings of Strategic Air Power*, 118.

5.5 British BDA Capabilities at the End of the Interwar Period

From 1 January 1936 to 1 September 1939, British air intelligence capabilities grew from infancy to adolescence. New intelligence organizations, reconnaissance aircraft, and the first cadre of RAF photointerpreters joined photographic specialists and cameras, both of which had already reached a relatively mature state, to provide the first clear indication that a new BDA intellectual infrastructure was emerging. It would take a war to bring this process to completion, but once the infrastructure was mature, by the end of 1942, it played a vital role in the bombing effort and, by extension, in the Allied victory.

5.6 BDA in the Late Interwar Period: The American Experience

The American experience with development of BDA-related capabilities in the late interwar period differed from that of the British. While the British did poorly with the development of operational bombing capabilities but well with the formation of air and economic intelligence organizations, the case was reversed for the Americans, who developed clear doctrine, an excellent heavy bomber and bombsight, good bombs, and good navigational equipment and skills, but at the same time lagged behind the British in their development of air and economic intelligence organizations, and targeting and BDA capabilities. As it turned out, this worked to the advantage of both the Americans and the British, with the former benefiting from mature British targeting and BDA capabilities and the latter from the addition of hundreds, and then thousands, of American heavy bombers to augment Bomber Command operations against Germany. This reminds us that if high-altitude, precision, daylight bombardment doctrine was a doctrine in search of an airplane, as several scholars have observed, it was also a doctrine in search of a serious air intelligence capability, including targeting and BDA expertise. The Air Corps was

acquiring the former by 1939 but had hardly considered the latter. In fact, it would be the British who stepped in to correct this rather colossal oversight on the part of the Air Corps. Arnold and his lieutenants were forward thinkers in the realm of air warfare, but their deep thought did not extend to air intelligence. This was nowhere more evident than in their almost complete lack of emphasis on BDA until a few months before America's entry into the Second World War. What they did have the presence of mind to do—and this proved crucial to the exceptionally close wartime partnership between British BDA and American aerial bombardment—was to send Air Corps officers to Great Britain as observers, not just of British flying operations, but also of their air intelligence activities. It was the latter which impressed them the most, and the recommendations they made based on their findings would play a vital role in the development of an American BDA capability—one that appeared much later than it should have and which was an adjunct to the British capability, but one that worked nonetheless.

5.7 Bombardment Doctrine and Training: America's Strong Suits

By 1934, the U.S. Army Air Corps was well on the way to developing a heavy bomber capability. Five things had begun to come together by this time to make such a capability, if not a present reality, then a nearly certain future reality. These included the development of doctrine for the employment of heavy bombers, the arrival of the B-17, an aircraft in many ways ideally suited to the new doctrine, the Norden bombsight, better bombs and fuses, and the intensive training of aircrews in day and night navigation and in employment of the Norden bombsight. The organization at the center of doctrine development for aerial bombardment was the Air Corps Tactical School (ACTS) at Maxwell Field, Alabama, which, as Peter Faber has noted, was “the incubator of

bombardment theory and doctrine” for an entire generation of American airmen—the same generation that would be called upon to put these doctrinal ideas into practice in the skies over Italy and Germany. Faber said that ACTS doctrinal development progressed in three stages. From 1920 to 1926, the ACTS faculty established the primacy of the bomber as an instrument of air warfare, a development glimpsed in the previous chapter. During the middle period, 1927 to 1934, they developed a uniquely American doctrine: high-altitude, precision, daylight bombing. It was unique for the simple reason that the British, despite the lip service they gave to high-altitude daylight bombardment, never made anything like the concerted effort the Americans did to bring this doctrine to fruition as an operational reality. The key hallmarks of this doctrine included concerted, systematic, and heavy attacks against an enemy’s industrial infrastructure, focusing on target sets most likely to bring about an enemy’s military collapse. During the third phase, 1935 to 1940, ACTS instructors formalized their doctrine by trying to determine which target sets constituted key vulnerabilities in Germany’s war economy.⁵⁶

Faber also notes that the best and brightest officers attended ACTS and were thus inculcated with the new doctrine. From 1921 to 1940, ACTS graduated 1,091 officers. Of these, 261 became general officers, comprising 80 percent of the U.S. Army Air Force senior leadership during World War II, including 11 of its 13 three-star generals and all three of the four-star generals. These men believed in the new doctrine, and when they took command of the American bombing effort during the Second World War, their faith in the ability of the heavy bomber to produce decisive effects on the enemy’s war

⁵⁶ Faber, “Interwar US Army Aviation and the Air Corps Tactical School: Incubators of American Airpower,” 211.

economy was unflinching.⁵⁷ This clarity of purpose marked one of the great strengths of the evolving American aerial bombardment capability. It kept senior airmen focused on the idea that attacking key target sets such as oil and transportation could pay large dividends in any future armed conflict. This steadfast belief in the efficacy of their primary weapon system was important because it turned out, for the most part, to be justified by the transportation and oil offensives during the Second World War.

Training standards for bomber crews were also exceptionally high compared to those of the British because the Americans flew more often and under more varied conditions. In fact, the Americans set clear and high standards for their bombardiers. To qualify as a Bombardier 3rd Class, officers had to be able to drop practice and live bombs from 20,000 feet of altitude with a maximum circular error probable of 500 feet for day missions and 600 feet for night missions.⁵⁸ This accuracy derived in part from high training standards, in part from the Norden bombsight and the B-17 bomber, and in part from the fact that most—but not all—bombing practice was conducted in clear weather. Of course, there were no enemy fighters and antiaircraft artillery to contend with, which also made things easier. Nonetheless, American bombing standards and proficiency were the highest in the world by 1941, and remained so, with the possible exception of the best British bomber crews (more on them in subsequent chapters), until the end of the war.

5.8 Targeting and BDA: America's Weak Suits

Despite the strengths of American bombing doctrine, it also contained serious flaws. Not the least of these was the zealotry of the ACTS bomber advocates in asserting that

⁵⁷ Ibid., 211-212.

⁵⁸ AFHRA 167.5-89, War Department, Tentative Training Manual No. 2170-105, Air Corps, Precision Bombing, 11 January 1940. Circular error probable is the radius of a circle within which 50 percent of the bombs land.

airpower alone could defeat an industrialized enemy in a future war. Equally problematic was the woefully inadequate air intelligence infrastructure available to provide targeting data, and the almost utter lack of attention to BDA. This comprised one of the greatest ironies, and one of the most important, in the development of bombardment aviation during the late interwar period. Given the doctrinal emphasis on precision bombing, both targeting and BDA should have been at the center of the airmen's concerns. Instead, with the partial exception of targeting, they existed at the margins until 1943 and never received the intensive developmental efforts seen on the British side. This relative lack of interest in targeting and BDA, including key technologies such as high-performance reconnaissance aircraft, placed the Americans at the mercy of their British allies. Fortunately, the British proved willing to share their air intelligence, teach their American counterparts the key elements of targeting and BDA, and treat them as equal partners.

Strangest of all, however, was the failure to recognize *in ACTS courses* the need for these capabilities. The course on military intelligence for academic year 1939-40 described aerial photography almost entirely in terms of its support to ground operations. Photointerpretation was seen as a skill for analyzing aerial photographs of the enemy's front lines and immediate rear areas, and for creating annotated photo mosaics of them. This was odd given the Army Field Manual on intelligence procedures in aviation units, which at least acknowledged that air warfare could involve "independent operations" against an enemy's industrial infrastructure.⁵⁹

⁵⁹ AFHRA 248.5009 D-10, ACTS Manual, "Military Intelligence," Academic Year 1939-40, 1-7; AFHRA 248.5009 D-9, War Department, Air Corps Field Manual FM 1-40, *Intelligence Procedure in Aviation Units (1939-40)*, 7.

On the other hand, an ACTS course on observation aircraft for academic year 1938-39, taught by Captain K. P. McNaughton, proved quite forward-looking in its emphasis on the requirement for different types of reconnaissance aircraft based on their likely employment. The course materials noted that high speed, high altitude, and long range were the attributes most important for a dedicated reconnaissance platform, which McNaughton clearly advocated. "The trend in thought today in practically all countries," he said, "is that there is a need for a fast long distant [sic] reconnaissance aircraft capable of developing [in other words, reaching and covering] all objectives within striking range of bombardment aviation."⁶⁰ McNaughton emphasized that aerial photography was destined to be the most important means of obtaining detailed information, noting that the perfection of the Fairchild K-7A camera, with a 24" focal length and a 9"x18" negative, provided photographs of unprecedented detail and quality, each of which covered an area of four square miles from 20,000 feet. This recognition of the importance of long-range photoreconnaissance aircraft was at odds with the otherwise glaring lack of interest among the ACTS faculty in advocating the development of serious BDA capabilities.

The real problem with the ACTS faculty therefore appears to have been a blind faith brought on by overconfidence. If the B-17 and Norden bombsight could destroy key target sets within an enemy's war economy, and if the bomber crews could get their aircraft over these targets and drop their bombs, there would be no need for a serious BDA capability. They made a similar error with respect to targeting, an incomprehensible lapse of judgment given their fixation on attacking key *target sets*.

⁶⁰ AFHRA 248.262-35, ACTS, Captain K. P. McNaughton "Observation Airplanes and Their Equipment" (Academic Year 1938-1939), 15, 17, 23.

Major General Haywood S. Hansell, who as a major played a central role in developing the doctrine, subsequently admitted that as late as 1939 nobody seems to have recognized the vital importance of careful industrial analysis for choosing the most vulnerable target sets. Because the Air Corps effectively ignored this issue during the late interwar period, the American air intelligence effort started very late and floundered for its first two years.

Unfortunately, *nobody*, including the Chief of the Air Corps, General Hap Arnold, began thinking seriously about air intelligence prior to 1940. In fact, not until November 1940 did Arnold officially establish an Office of the Chief of Air Corps Intelligence Division. When the Air Corps became the Army Air Forces on 20 June 1941, Arnold did insist on having his own Assistant Chief of Air Staff, Intelligence (ACAS A-2), and General George C. Marshall, the Army Chief of Staff, agreed. Arnold's first ACAS A-2, Brigadier General Martin Scanlon, managed to convince Arnold and Marshall that air intelligence must include target intelligence, but there was no discussion of BDA. So it was at this point, *five months* before the United States entered the war, that a *recognition* of the importance of target intelligence at the highest levels finally emerged. But recognizing a problem and addressing it are two different things, and the Army Air Forces proved unable to do the latter for months.⁶¹

Ironically, BDA received its first real push not from the ACTS faculty, who ignored it, nor from Arnold's staff, but from Major C. P. Cabell, who Arnold sent to Great Britain in February 1941 to learn about aerial photography and photointerpretation. Cabell submitted his report to the Army G-2 in May 1941, where it sat for almost three months

⁶¹ Interview, Colonel Thomas A. Fabyanic, USAF, Ret., with Major General Haywood S. Hansell, Jr., USAF, Ret, 21 January 1987, referenced in several notes in Kreis, ed., *Piercing the Fog*, 425-427; Kreis, ed., *Piercing the Fog*, 28, 41-44.

before Arnold's staff received access to it. This was part of a "turf war" between Arnold and the Army G-2, Major General Sherman Miles. One of the things that had made Arnold furious over the past two years had been Miles's refusal to give him and his staff access to reports from military attachés and observers, all of which were sent to Miles's office. Marshall ruled that Arnold and his staff must have unfettered access to such reports, but also that A-2 officers had to work through G-2 to collect target intelligence. This was a compromise to mollify Miles, but it resulted in a *modus vivendi* by which A-2 targets officers could collect the intelligence they needed. One of the first things they did was delve into Cabell's report, which yielded many vital insights.

5.9 Aerial Photography, Photoreconnaissance, and Photointerpretation

Cabell's mission was "to study aerial photography in Great Britain," a job he did very well. His recommendations, all of which the Army Air Forces adopted, paid huge dividends for the development of American targeting and BDA capabilities. These included formation of an Army Air Forces agency to formulate photographic policies and coordinate research, development, testing, and evaluation of new capabilities for conducting various methods of aerial photography; immediate formation of one or more Photographic Groups, including a Photoreconnaissance Group equipped with the latest pursuit aircraft; immediate establishment of an Air Intelligence School to train photointerpreters as well as combat intelligence officers; the formation of several photointerpretation units; and the creation of standing committees under the chairmanship of the Photographic Representative, Operations Division, Office of the Chief of the Air Corps (later HQ Army Air Forces). The fact that Cabell later became a general officer,

and the Chief of Operations and Intelligence for Mediterranean Allied Air Forces, says something about his judgment and the degree to which he impressed senior airmen.⁶²

Cabell's reports of his visits to various British air intelligence organizations comprised a veritable Who's Who of key British personnel either already discussed in this work or soon to be so. He began with a visit to Group Captain F. C. V. Laws, who was by this time the Air Ministry's Deputy Director of Photography. From there, he toured the Ministry of Aircraft Production's Research and Experiments Section at RAF Farnborough, where he spoke with the Research Director of Photos, and Photographic Reconnaissance Unit No. 1 (PRU1) at RAF Benson, where he learned a great deal about the photoreconnaissance business from the Air Officer Commanding, Wing Commander G. W. Tuttle. Cabell then paid a visit to Bomber Command Intelligence, where he met Squadron Leader P. G. Heath, Chief Photointerpretation Officer, and to Photographic Reconnaissance Unit No. 3 (PRU3) at RAF Oakington, which was Bomber Command's dedicated unit for obtaining BDA photos, where he met with Squadron leader P. B. B. Ogilvie. At both locations, he focused on the methods for collecting, analyzing, and disseminating BDA reports for Bomber Command raids. He continued this discussion with station intelligence and photointerpretation officers at several bomb squadrons. Perhaps most important, however, was his visit to the Central Interpretation Unit (CIU), the RAF's centralized photointerpretation facility, where he had a long discussion with the Commanding Officer, Wing Commander H. Hemming, and toured the facility.⁶³

⁶² AFHRA 168.7026-2, Major C. P. Cabell, "Final Report of Military Air Observer to Great Britain," 7 April 1941, 1.

⁶³ These key British organizations and personalities will receive a much more detailed look in the following chapter, but the important thing at this point is to demonstrate what Cabell learned from them and the ways in which his subsequent recommendations influenced Army Air Forces targeting and BDA efforts.

Cabell's most urgent recommendation was that the Army Air Force leadership field a dedicated *and survivable* photoreconnaissance aircraft as quickly as possible. During his first stop in Great Britain, the Air Ministry, Cabell learned from the Assistant Chief of Air Staff, Air Vice Marshal Peck, that nearly 80 percent of photoreconnaissance missions flown by Blenheim and Lysander aircraft during the first month of the war failed to return. Consequently, Peck noted, the requirement for the photoreconnaissance version of the Spitfire became urgent. Peck further noted that the British policy was to provide photoreconnaissance units with "the fastest variants of the fastest aircraft." He emphasized that "The photographic airplane must be the cream of the cream, as its only defense lies in its power of evasion."⁶⁴

Cabell then noted that "The interpretation of aerial photographs requires more than a casual study by the average individual. It requires an exhaustive study by specially trained and experienced men, backed by an organization able readily to obtain factual confirmation of the suspected identity of an object on the photograph." In what could only have been a stinging rebuke to the lethargic pace of American air intelligence capabilities up to that point, Cabell continued with the assertion that "The compilation of objective folders including target maps is primarily a peace-time activity that must be continued in war time." Even more important was the superb coordination between British military and civilian intelligence experts in targeting and BDA. The key to this success lay in the committee system established to address these issues. These

⁶⁴ AFHRA 168.7026-2, Major C. P. Cabell, "Final Report of Military Air Observer to Great Britain," 7 April 1941, 2.

committees provided a forum where experts met frequently in order to discuss emerging capabilities and initiatives while solving problems of various kinds.⁶⁵

Cabell was also very impressed with the smooth operation of PRU1 and, even more importantly, the excellent coordination between this unit and its counterpart, the CIU. He emphasized that British air and economic intelligence agencies depended to a great extent on aerial photographs for their information. Cabell was particularly taken with the system the British had worked out for their photointerpretation and BDA efforts, both of which involved 1st, 2nd, and 3rd phase interpretation. The 1st phase was conducted at PRU1 and PRU3 by photointerpreters stationed at those two units. They were required to complete a very rapid interpretation of all photographs taken during each sortie and send their key findings via teletype to CIU, Bomber Command, Air Ministry, and other interested parties within one to two hours of receipt of the photographs, followed by a courier delivery of their annotated photographs and textual reports. This 1st phase effort was restricted to "that information which might have an influence on the day to day conduct of the war." An example Wing Commander Hemming, the Commanding Officer of the CIU, gave Cabell was the movement of a large number of barges between the English Channel ports in France, Belgium, and the Netherlands, an important event in 1940 and early 1941 that might have presaged an attempted German invasion of Great Britain. Similarly, photointerpreters at PRU3, who studied all the aerial photographs taken by the unit's photoreconnaissance aircraft of the results of Bomber Command raids, were responsible for providing immediate damage assessment reports for BDA purposes. Once 1st phase reports were completed, 2nd phase interpretation, which was to be

⁶⁵ Ibid., 3.

completed in 24 hours, occurred at the CIU and included detailed interpretation of the subject at hand, whether a new airfield, a recently built or expanded industrial facility, or the results of a Bomber Command raid. During this phase, expert photointerpreters in each sub-field of their business, whether interpreting airfields or oil plants, or conducting detailed BDA, took the time needed to tease out all the information each aerial photograph had to offer. Finally, Cabell said, 3rd phase interpretation consisted of special and detailed studies of some aspect of the German war economy or military forces, produced by experts in the field, with limited distribution for strategic assessment and planning purposes. The Ministry of Economic Warfare, for example, produced reports, quarterly, semi-annually, or annually, on the effects and effectiveness of the bombing of Germany. Similarly, Research and Experiments Department 8 (RE8), located at the Ministry of Home Defence and later at the Air Ministry, provided detailed BDA and MEA reports for specific raids and munitions, and detailed reports on repair and reconstruction of industrial and military facilities attacked by bombers.⁶⁶

Despite the tight security during Cabell's visits to PRU1 and the CIU, the degree of trust the British had in their visitor and his government became clear when Wing Commander Hemming sent him a detailed paper, entitled "Organisation of the Central Interpretation Unit," about a month after his visit to the CIU. This paper provided a number of key insights on CIU operations. Among these were what Hemming called the "Three Basic Principles of Photointerpretation". The first of these was that "The success of an Interpretation Unit is based upon the efficiency of its training section..."

⁶⁶ AFHRA 168.7026-2, Major C. P. Cabell, Report No. 42413, "Aerial Photography: Organization and Operation of Photographic Reconnaissance Unit Number One, Benson, England," 21 February 1941, 4; and Report No. 42415, "Interpretation of Aerial Photographs," 21 February 1941, 1-2.

Accordingly, the CIU conducted all training of photointerpreters in-house, with new graduates apprenticing in their operational capacities under the tutelage of experienced interpreters until deemed ready to conduct detailed interpretation on their own.

Hemming's second principle was that "As many opinions as time allows must be obtained on areas covered." Pairs of interpreters therefore cross-checked one another, then discussed their work with their Duty Interpretation Officer (the senior interpreter on shift in their duty section), who also checked it for analytical rigor. For 2nd phase reports, photointerpreters also sought expert guidance from civilian or military analysts at MEW, RE8, specialized government intelligence offices such as the Railroad Research Service, or from civilian contacts such as industrial or oil experts, many of whom had designed, built, managed, or visited various facilities in Germany or German-occupied Europe. In turn, these MEW and RE8 analysts coordinated their work closely with photointerpreters at the CIU. The third of Hemming's rules was that "All comparison photographs and information of all kinds must be available for the interpreter so that he can compare the detail he obtains from any one sortie with that information obtained of the same area from all sources." This was what intelligence personnel now refer to as change detection. By looking at the same installation over a period of months, interpreters were able to detect minute changes, some of which pointed to developments of great significance. At the close of their meeting, Hemming offered Cabell this advice: "The production side of an interpretation unit," he said, "must be as efficient as a business concern."⁶⁷

⁶⁷ AFHRA 168.7026-2, CIU, "Organisation of the Central Interpretation Unit," 21 March 1941, 4-5; Major C. P. Cabell, Report No. 42415, "Interpretation of Aerial Photographs," 21 February 1941.

This was a revealing statement when considered in light of Hemming's "Three Basic Principles of Photointerpretation" because it reminds us that two very Western traditions were always at work in the BDA business: the scientific method, which provided a systematic and rational approach to dealing with questions surrounding the German war economy and the effects and effectiveness of Allied attacks against it; and a business process designed to achieve the maximum efficiency and effectiveness from a given worker or process. It was, in other words, the adaptation of rationalism and capitalism to war, a process the nation-states of the West had been engaged in for the past three hundred years and which reached new heights in Anglo-American intelligence and operations during the Second World War.

Second in importance only to Cabell's tours of PRU1 and the CIU was his long visit with Group Captain F. C. V. Laws, the Air Ministry's Deputy Director of Photography. While Cabell felt Laws had more on his plate than he could handle, he also saw great value in a centralized office responsible for all RAF aerial photography. Group Captain Laws coordinated and directed photographic policy in the RAF, coordinated all Air Ministry branches concerned with photography, acted as liaison with the Ministry of Aircraft Production on issues relating to development and fielding of photographic equipment, provided data to the Director General of Equipment to implement photographic purchases, and served as Chairman of the Standing Advisory Coordinating Committee on Photography, and as a member of the Directorate of Scientific Research Photographic Committee. Laws emphasized that photographic matters had not been well coordinated until his position was established, but that since then there had been real coordination between the organizations responsible for research, development,

procurement, training, and operations. As a result, British aerial photography had recently made huge strides. Laws concluded his comments with a reminder that the synergy between his organization and the PRUs was outstanding because the latter were ready-made testbeds for all new equipment, allowing for a rapid research, development, testing, evaluation, and fielding process. The only weakness Cabell saw in British aerial photography was a shortage of cameras aboard bombers for taking strike photographs. During night bombing raids, for instance, only one aircraft in each squadron formation of 12 carried a camera, usually in 10th position. If that aircraft was lost, the squadron had no strike photographs. Although the British were in the process of installing additional cameras, Cabell recommended that the Americans bypass this shortfall at the outset by installing adequate numbers of cameras *before* their bombers began flying combat missions. Arnold listened, and when American bombers deployed across the Atlantic to Great Britain, every second one had cameras installed.⁶⁸

Cabell's report was considered so valuable that another Army Air Forces officer, Major D. W. Hutchison, was sent to Great Britain in October 1941 to gather additional information and to validate information Cabell gathered during his trip. Hutchison visited the CIU's Training School at RAF Nuneham Common, located adjacent to the main CIU operation at RAF Medmenham, noting that primary training lasted four weeks with classes ranging from 25 to 30 students each. Three instructors taught students how to identify a wide array of objects from operational aerial photographs. In addition to classical PI work, students also learned map reading, plotting, determination of scale on

⁶⁸ AFHRA 168.7026-2, Major C. P. Cabell, Report No. 42470, "Aerial Photography," 28 February 1941, 1-3; Report No. 42560, "Procurement and Manufacture of Aerial Photographic Equipment," 13 March 1941, 1-2; Report No. 42560, "Aerial Photography," 14 March 1941, 2; Stanley, *World War II Photo Intelligence*, 94.

aerial photographs, and report writing. He noted the British view that selection of students with the right qualities was much more important than the training itself. These qualities included an eye for detail and patterns, an ability to see in stereo, at least 20/20 vision with no astigmatism, and an analytical creativity that allowed them to make sense of disparate images and determine their interrelationships. Hutchison, who saw the great value in this process, requested copy negatives of all CIU training photographs and associated intelligence reports in order to have a "starter kit" once the USAAF leadership established an American photointerpreters' school. The Air Ministry granted his request and expressed a willingness to send the director of their school, Flight Lieutenant Stephenson, and two assistants to help establish a similar school in the United States and teach the first few courses. Hutchison therefore recommended that the Army Air Forces set up aerial interpretation school immediately, that the ACAS A-2 request the services of Flight Lieutenant Stephenson and the two other RAF officers, and that the new school be up and running by 1 February, 1942. Arnold and Scanlon approved and established the Army Air Forces Air Intelligence School on 16 February 1942 at College Park, Maryland. The school moved to Harrisburg, Pennsylvania, in April 1942, and in 1944 became the Intelligence Division, School of Applied Tactics, in Orlando, Florida.⁶⁹

Hutchison also reconfirmed the value of the PRUs and CIU, noting that in a conversation with Air Vice Marshal Fred Inglis, the Air Ministry's Assistant Chief of Air Staff (Intelligence), Inglis estimated that over 80 percent of RAF intelligence came from aerial photographs. He further noted that the work done by the PRUs was so important

⁶⁹ AFHRA 168.7026-2, Major D. W. Hutchison, Report No. BES-227, "Central Interpretation Unit Training," 27 October 1941, 1-2.

they received first priority for all improved and new aircraft types. At the time of Hutchison's meeting with Inglis, PRU1 had 40 Spitfires and six Mosquitoes assigned and flying a variety of missions from the collection of BDA photographs to reconnaissance flights against German naval targets and airfields. British reconnaissance aircraft had also primary and secondary objectives, which meant they almost always brought back photos of something of value to the German war effort and, thus, to British intelligence.⁷⁰

One other American visit deserves brief mention here. In the summer of 1941 Haywood Hansell visited the Air Ministry in the summer of 1941, during which Air Vice Marshal Inglis gave him nearly a ton of documents, mostly classified target folders, to assist the American Air Staff with their targeting efforts. Hansell was able to requisition an American bomber to haul his treasure trove of classified documents back to Washington D.C., where they augmented the small but rapidly growing collection of target materials in the offices of the ACAS A-2.⁷¹

In October 1940, four months before Cabell's important visit to Great Britain, a board of photographic officers convened in the Office of the Chief of the Air Corps to study and make recommendations concerning Air Corps photographic problems. The board, which included Major George W. Goddard, set out "to determine the peace and war tactical requirements of photographic equipment and supply, including equipment development priorities, personnel and training thereof, and will specify objectives toward which all efforts should be directed to meet the tactical requirements of Air Corps

⁷⁰ AFHRA 168.7026-2, Major D. W. Hutchison, Report No. BES-281, "One Week's Visit to the P.R.U. at Benson," 27 October 1941, 1-2.

⁷¹ Hansell, *Strategic Air War against Germany and Japan*, 24.

photography.”⁷² The most urgent of its recommendations was that the Air Corps work with civilian industry to develop a world-class optical glass industry. The only sources of high-quality lenses before the war had been Germany and Switzerland. Only the latter still provided any lenses, and those in small quantities. The board felt so strongly about this matter that they asked Major General Arnold to advise the Assistant Secretary of War of the critical need for these lenses. Further, they sought authorization for five photographic squadrons, three of which were to be formed and activated immediately. Finally, the board recommended that Arnold establish an Office of Chief Photographer.⁷³

Equally important were the manpower, supply, and equipment recommendations, which included revised tables of basic allowances and equipment to ensure photographic squadrons had ample supplies of the latest materials, including waterproof photographic paper and color-photograph materials. The board also proposed that a list of commercial photographers be maintained, and that during a national emergency the Air Corps commission them and send them to a special photographic course at the Air Corps Technical School at Lowry Field, Colorado.

The board also pushed for cameras on every bomber, a request that became a reality by 1943. Even more important, they placed at the very top of their “development program” list a photoreconnaissance aircraft with a pressurized cabin, a service ceiling of 35,000

⁷² AFHRA 248.262-19, “Proceedings of a Board of Officers convened on photographic matters, War Department, Office of the Chief of the Air Corps,” 7 Oct 1940, 2.

⁷³ Ibid., 8-12. The committee requested for \$103,000 for technical development, including rolled glass, plastic, and wide-angle lenses; high-speed between-the-lens shutters; a synchronized, stabilized, panoramic camera; screens and filters for color photography; film-stenciling implements for rapidly marking negatives; electric spark flash lamps for night photography; infrared film; a high-speed 14” focal-length lens; and a single-picture, tri-vision stereoscopic camera. In addition, they asked for \$105,000 to field new cameras, including a light, simple, general purpose aerial camera for installation in every observation, bombardment, and reconnaissance airplane; photographic flash-bombs; lightweight photographic laboratory equipment; a telephoto aerial camera with 20 and 40 inch focal lengths; an air-portable photographic laboratory; and a ground-mobile photographic laboratory.

feet, an automatic pilot, and remote camera control. This aircraft, the XB-28A, never went into production. Arnold approved most of the board's recommendations on 18 September 1940 and directed that "All interested Divisions in the Office, Chief of Air Corps, will institute the necessary studies immediately, designed to place these recommendations in operation." Sadly, he never did place emphasis on fielding the XB-28A or another equally capable aircraft.⁷⁴

The photographic board's recommendations rested in large measure on George Goddard's many accomplishments during the late interwar period. After a tour in the Philippines, Goddard once again jumped vigorously into the aerial photography business, focusing on three major initiatives between 1937 and 1942: the strip camera, night photography, and a new generation of telephoto lenses. Goddard realized that if he could find a strip camera whose film speed could be synchronized with the airspeed of a reconnaissance aircraft, it would be able to shoot continuous and stereoscopic coverage of reconnaissance targets without the need for 60 percent overlap between exposures. Goddard had a battle royal on his hands with the Air Corps procurement agencies, which saw the high cost of the technology but not its great importance. Goddard also worked with scientists at the Massachusetts Institute of Technology to develop a photoelectric flash system for night photography to replace the unreliable flash bombs, and he pitched full tilt into the development of a new generation of telephoto lenses.⁷⁵

Goddard was shocked to discover that the 36-inch lens he had developed with Eastman Kodak had been put on display in the Wright Field museum. He immediately

⁷⁴ Ibid., 9, 12, 38.

⁷⁵ Goddard, *Overview*, 240-244.

set to work on a new generation of lenses based on this older model but with focal lengths of 40, 50, and 60 inches to take color and black-and-white high-resolution photographs from altitudes as high as 40,000 feet. By 1938 he had succeeded in putting a 40-inch Bausch & Lomb lens into a standard K-7 Fairchild camera. Despite this accomplishment, Goddard faced an even more fundamental problem: American-made lenses were inferior to those made in Germany and Switzerland. To resolve this crucial issue, Goddard hired Dr. James Baker, an astronomer at Harvard University, who had developed superb lenses for telescopes at the university's observatory. Baker designed Goddard's 40-, 60-, and 100-inch camera lenses, which were the forerunners of today's satellite cameras, and Amron Katz, a brilliant physicist, brought together Baker's lenses with his camera shutter advances, resulting by 1942 in the world's best cameras.⁷⁶

Arnold made additional funds available for the development of all other aspects of aerial photography, which allowed Goddard to procure the new lenses he had been developing and, in late 1940 and early 1941, offer commissions to a number of highly-qualified civilian photographic experts and bring back to active duty other specialists who were in the reserves. This was another indication that American officers, like their British counterparts, worked hard to find the most qualified people to fill various air intelligence positions, a strength that acted as a major force multiplier during the Second World War. In March 1941, Goddard was also able to bring the first RAF liaison officer to Wright Field, Ohio, where he coordinated the American and British aerial photography efforts to maximize synergy and minimize duplication of effort.⁷⁷

⁷⁶ Ibid., 246, 276.

⁷⁷ Ibid., 272, 280, 291, 293.

5.10 Continuing Improvements in American Bombs and Fuses

American airmen stayed ahead of their British counterparts in the development and testing of aerial munitions during the late interwar period. A table produced for a conference held at the end of 1939 to discuss the effectiveness of bombs against various kinds of targets included 12 separate bomb types, from 100-lb. to 2,000-lb., and noted the crater dimensions they produced in soil and solid rock, and their blast effect on reinforced concrete. Similarly, an ACTS course on bombs provided a detailed look at the effects of various bombs on different kinds of targets, emphasizing that bombs of the proper size with the right fuses were crucial. In December 1940, the Air Corps Board, established to oversee the development of aircraft, bombs, fuses, and ground equipment, published the first systematic study of differences in accuracy at various altitudes. Bombing at 2,500 feet of altitude produced CEPs of between 100 and 140 feet, while bombing from 20,000 feet of altitude produced CEPs of between 320 and 460 feet.⁷⁸ Although the difference in accuracy appears large at first glance, it is worth noting that CEPs were only about three times larger at 20,000 feet, even though the altitude from which test bombs were dropped was *eight* times greater. The Norden bombsight, while far from providing “pickle-barrel” accuracy, was nonetheless a major improvement for high-altitude bombing.

There was also a steady move towards larger bombs, with 1,000-lb. general-purpose bombs making their first appearance, and an ongoing exchange of technical information on aerial munitions between the Americans and the British, with both parties benefiting

⁷⁸ AFHRA 248.6282-7, The Command and General Staff School, Conference, “Effectiveness of Demolition Bombs against Specific Objectives,” 1939-1940, 3, Table 1; AFHRA 248.2208A-3, ACTS, lecture text, “The Power and Effect of the Demolition Bomb” (Academic Year 1938-1939), 6; AFHRA 167.5-58, “Preliminary Report of The Air Corps Board, Study No. 58, Comparison of Glide and Low Altitude Bombing with High Altitude Bombing,” 7 December 1940, Figure 1.

from the British analysis of German bombs dropped on their country. A memo produced in September 1941 contained detailed information on all British and German bombs currently in use, noting every important characteristic, including total weight, casing-to-explosive weight ratio, overall size, and distance from nose fuse to center front lug. The memo noted that "There has been a quite definite trend by the British to use larger type bombs than were first considered necessary to accomplish the destruction of buildings. There seems to be a definite trend on the part of the British to go to larger, thin case bombs as much as possible." This was based on the growing British recognition that German bombs, which were thin walled and fused instantaneously, had a much more destructive blast effect than British bombs, which early in the war had thick casings. In addition, the memo raised the possibility of an Air Corps Board study to compare the effects of American and British bombs so American ordnance officers would know which of these bombs were most effective against specific targets. The task was especially important in view of the possibility that American bombers might have to drop British bombs during their first few month of operations, until American bomb production became adequate to the task of supporting major air campaigns. Needless to say, by this time the British had caught up to the Americans and in many ways passed them in the design and production of effective bombs, but it took two years of war to get them to this point. Given that the Americans were at peace until the last month of 1941 and benefited from the exchange of technical information with the British only after 1940, they did well before that time in the development of increasingly large and effective bombs with a growing variety of fuses to maximize effects against different types of targets.⁷⁹

⁷⁹ AFHRA 248.3794, Air Corps, "Sizes of British Bombs Used against Germany," 10 September 1941, 1-2.

5.11 BDA at the End of the Interwar Period

The British and Americans entered World War II without mature BDA intellectual infrastructures. However, the British had come much closer to building one by September 1939 than the Americans had by December 1941. The reasons for this have to do with a greater British appreciation for the importance of capable air and economic intelligence agencies, working in close cooperation, and fed with a steady stream of high-quality aerial photographs. The Americans, on the other hand, focused on bombing doctrine, heavy bombers, and advanced bombsights. A *de facto* operational capability had therefore begun to emerge by the time they entered the war. The British paid for their lack of emphasis on operational capabilities with outrageously inaccurate bombing until 1942, which, ironically, their effective BDA was able to highlight, a process culminating in the publication of the Butt Report in August 1941, which concluded that only one of every three Bomber Command sorties dropped bombs within five miles of the target.⁸⁰ The Americans, on the other hand, paid for their lack of emphasis on the development of targeting and BDA capabilities with an almost complete reliance on the British for these vital services, which, to their credit, they provided freely and graciously. This arrangement, though far from ideal in the Americans' estimation, worked quite well because it paired a strong American bombing capability with a highly capable British BDA capability. Getting there, however, required three years of concerted British efforts to develop an intellectual infrastructure capable of providing "precision BDA" to Bomber Command and, once they joined the effort, the USAAF's 8th and, later, 15th Air Forces.

⁸⁰ AFHRA 512.041-26, Air Ministry, Air Historical Branch 1, *The RAF in the Bombing Offensive against Germany, Vol. 1, Prewar Evolution of Bomber Command, 1917-1939*, Vol. III, 1945, 41-43.

One of the most striking things about BDA-related developments during the interwar period was the role played by a handful of individuals in preserving and advancing of various elements of the infrastructure. Goddard and Laws present the most obvious cases with their work in advancing aerial photography. Others include Dr. Baker, who produced high-quality lenses for Goddard's new telephoto-lens cameras, and Harry Stringer, who figured out how to mount cameras in the first photoreconnaissance Spitfires. And there is Sidney Cotton who, along with "Shorty" Longbottom, played a vital role in the development of both PRU1 and the CIU, the photoreconnaissance and photointerpretation elements of the British BDA capability.

Equally significant, on the British side, was the emergence in the late interwar period of the air and economic intelligence agencies that ultimately provided the BDA required to gauge the effects and effectiveness of Allied bombing, and, just before the war, of the first photoreconnaissance and photointerpretation organizations capable of collecting, producing, and interpreting the high-resolution photographs so central to the development of BDA capabilities. As the war progressed, these agencies developed an increasingly close and productive working relationship, one that grew stronger once their American counterparts arrived in Great Britain to augment the targeting and BDA processes. This process resulted by 1944 in a mature *Allied* intellectual infrastructure. Of course, the British had a great deal of work to do before these things came to pass, and it is to their development of the intellectual infrastructure between 1939 and 1942 that we now turn.

CHAPTER 6

BDA GROWS TO ADOLESCENCE: BRITISH BDA DEVELOPMENT, 1939-1941

The caveat 'photo confirmed' on a World War II order-of-battle, target analysis, situation report, or intelligence estimate was a hallmark of authenticity. No other source of intelligence was so readily accepted by the brass.¹

- Colonel Roy M. Stanley II, USAF, Retired

6.1 Early Bombing and Photoreconnaissance Efforts, 1939-1940

When war came, the British were unprepared both doctrinally and operationally to conduct any sort of serious bomber offensive. Nor was the intellectual infrastructure for BDA anywhere near complete. Some promising developments had occurred with the creation of new air and economic intelligence organizations, but the Ministry of Economic Warfare (MEW) did not come into existence until September 1939, nor were its relations with the Air Ministry and the Joint Intelligence Sub-Committee (JIC) either well defined or particularly rosy at the outset. Sidney Cotton was hard at work building an effective photoreconnaissance capability and a matching photointerpretation capability, which would ultimately result in the creation of the Photographic Reconnaissance Units (PRUs) and the Central Interpretation Unit (CIU). However, none of these key organizations existed prior to September 1939, and they did not begin to evolve and cooperate in a significant fashion until after the fall of France. In this sense, the period between September 1939 and the end of 1941 was a crucial one in the

¹ Stanley, *World War II Photo Intelligence*, 2.

evolution of these new organizations and the targeting and BDA expertise they ultimately brought to bear, with great effect, in support of the Allied war effort.

Operationally, a weak Bomber Command was both unable to fly effective combat missions against the Reich and prohibited from doing so by a nervous British government that feared massive German reprisal raids on London and other major cities if RAF bombers commenced any sort of air campaign against German targets. The Air Ministry's employment directive for British bombers stated that "Unrestricted air warfare is not in the interests of Great Britain."² The first British bombing campaign, such as it was, therefore consisted of dropping propaganda leaflets over western Germany at night and conducting small-scale maritime patrols in the North sea. In two of these patrols, on 14 and 18 December 1939, small formations of Wellingtons, flying unescorted, were attacked by German fighters and lost over half their numbers. Whatever plans Ludlow-Hewitt might have had for an air offensive against the Ruhr were now dashed by government and Air Ministry directives as well as the realization that British medium bombers could not survive in the daylight skies over or near the Reich.³

The first British bombing raid on Germany was, consequently, a night attack in retaliation for a German air raid on Scapa Flow. The attack, flown the night of 19-20 March 1940, targeted the Hörnum seaplane base on Sylt Island. Fifty medium bombers participated, with 41 of the crews reporting that they had visually identified the target and carried out successful attacks. The day after the raid, Prime Minister Neville Chamberlain announced in the House of Commons that he had ordered the attack, and

² AIR 9/131, Memo, Air Ministry, "The Employment of the Air Striking Force on the Outbreak of War," no date (probably late August 1939), 10.

³ Webster and Frankland, *Strategic Air Offensive*, Vol. I, 138-139.

British newspapers ran headlines announcing the destruction of the seaplane base. There was only one hitch: The entire force had bombed the wrong island, one in fact owned by Denmark, a rather embarrassing start to what would be a long, costly, and ineffective British bombing effort from 1940 to the end of 1941. Group Captain Arthur Harris, then in command of No. 5 Bomber Group, whose aircraft carried out the raid, reputedly told Flight Lieutenant Peter Riddell, in charge of HQ Bomber Command's Photointerpretation Section, not to emerge from his office until he found evidence of damage. Ultimately, Harris dispatched a Blenheim reconnaissance bomber to photograph the target area, and the bad news became official: Not a single aircraft had bombed the right target.⁴

Several important BDA-related operational realities made themselves clear during this unfortunate opening gambit. First, Riddell and his five fellow photointerpreters at HQ Bomber Command had in fact interpreted correctly both the strike photographs taken by the few camera-equipped bombers sent on the raid and the post-strike BDA photos taken by the Blenheim reconnaissance bomber after the raid. Second, a few onboard cameras were already present in the bomber force, a positive development from a BDA perspective, and these numbers would grow steadily over the next two years. Third, the primary platform for conducting post-strike reconnaissance was still the Blenheim, a slow and very vulnerable aircraft. Fourth, and most important for our purposes, the PRUs and CIU, which would soon provide the full range of targeting and BDA-related photographic services required to support a bombing campaign, from taking reconnaissance and BDA photographs to producing damage assessments, were not yet far enough along in their development to do these things. Nonetheless, they were evolving rapidly, and as the

⁴ Ibid., 140; see also Powys-Lybbe, *The Eye of Intelligence*, 25-26.

British bombing effort developed, slowly and hesitantly at first, and with increasing ferocity after 1941, British BDA capabilities, including those provided by the PRUs and CIU, the Air Ministry, HQ Bomber Command, and MEW, approached maturity.

One of the most glaring deficiencies in the evolving British BDA capability was the initial contingent of reconnaissance aircraft available to conduct missions over Germany. The only one with the combat radius to reach Germany—and only its western territories at that—was the Blenheim bomber, which flew at altitudes between 10,000 and 20,000 feet and proved itself unable to survive in the face of German fighter attacks. Of the first 89 Blenheim missions flown over Germany in 1939, 16 were shot down and half of the others failed to produce useful photographs due to evasive action and equipment malfunctions. The other aircraft in the British arsenal was the Lysander, a tactical reconnaissance platform similar to the German Fieseler Storch and the American Piper Cub, and equally vulnerable. From September 1939 to 15 January 1940, the RAF relied on the Blenheim and Lysander to photograph 2,500 square miles of German territory with the loss of 40 aircraft, while the French photographed 6,000 square miles at a cost of 60 aircraft. In contrast, Cotton's new reconnaissance detachment, now at RAF Heston, had photographed 5,000 square miles without the loss of a single aircraft, and in fact with only *one* aircraft assigned at this point. It was "Shorty" Longbottom who helped Cotton modify the first Spitfire by removing its guns, radio, and other unnecessary equipment and fitting it with extra gas tanks. This yielded a range of 1,500 miles (combat radius of 750 miles), enough to get to Berlin and back, a feat not long in coming.⁵

⁵ Price, *Targeting the Reich*, 9-10; Babington Smith, *Evidence in Camera*, 30.

Cotton argued ceaselessly at the Air Ministry not only for improved reconnaissance aircraft, but also for a *centralized* photoreconnaissance and photointerpretation capability in which all such assets were under Air Ministry control and part of a single and rational tasking process. He was responding to the haphazard method of tasking reconnaissance assets then in place, one in which the Air Ministry, Bomber Command, the War Office, the Admiralty, and the British Expeditionary Force in France were all expected to task, collect, interpret, and store their photographs using their own procedures and following their command's own imperatives, thus "stovepiping" the photoreconnaissance and photointerpretation functions in the early months of the war. These arrangements, far from being frowned upon by senior British officers, were in fact codified in a standing directive, War Instruction No. 5. This document stated which Service and subordinate units would provide aerial photographs and who would do the photointerpretation. Under this system, Bomber Command and Coastal Command, Admiralty Units B and C, and Army Field Forces or army Air Support Forces were all tasked to provide photographs, with interpreters at the various commands annotating the prints and producing associated reports. This was duplicative, wasteful of resources, and dangerous given the vulnerable aircraft involved in the process. Along with the reconnaissance aircraft problem, Cotton set out to fix this ineffective tasking, collection, production, and dissemination process.⁶

6.2 Photographic Development Unit and Photographic Interpretation Unit

The "Cotton Organisation," as the photoreconnaissance and photointerpretation capabilities ultimately comprising the PRUs and CIU were initially known, included

⁶ AIR 40/1495, Air Ministry, Directorate of Intelligence, "War Instruction No. 5, Distribution and Interpretation of Aerial Photographs," December 1939.

Cotton's SIS Flight, which continued to conduct photographic reconnaissance of factories and other high-value targets in Germany until the war began. Cotton's aircraft also photographed industrial facilities in the British Isles for comparative purposes and to fill in blank portions of the photointerpreters' recognition guides, giving them as much practice as possible learning to recognize and glean details from a wide range of aerial photographs containing high-value facilities. The "Cotton Organisation" also included the Aircraft Operating Company, an amalgamation of air survey companies and Aerofilm Ltd., a specialized company producing cameras, film, and other photographic supplies. The Aircraft Operating Company had originally been intended to provide an Empire-wide air survey capability and had among its equipment two Wild A.5 Stereo Plotters. These two organizations—SIS Flight and the Aircraft Operating Company—were located immediately adjacent to one another at RAF Heston and RAF Wembley to facilitate the rapid development, interpretation, annotation and dissemination of aerial photographs and associated intelligence assessments.⁷

Once war arrived, the Air Ministry requisitioned the Aircraft Operating Company's assets along with those of SIS Flight, including the first two reconnaissance Spitfires, to form No. 1 Camouflage Unit. Here, Cotton, who had been made a Wing Commander and placed in charge of the new unit, engaged in several technological and procedural innovations that made his unit the first to provide an initial and ultimately comprehensive centralized control of the high-value aircraft and analytical assets of No. 1 Camouflage Unit. Some of his more important initiatives included the outfitting of successive versions of his unit's Spitfires with increasingly capable cameras, and the implementation

⁷ These events received detailed discussion in Chapter 5.

of 24-hour operations in which all offices were manned around the clock and the analysts and other technicians worked one twelve-hour shift, had the next 12 hours off as leave, and then prepared and reported for duty at the end of a third twelve-hour period. During these early days, people often worked shifts of more than 12 hours and on occasion stayed at their desks for 24 hours straight and even more during the height of the invasion threat in the summer and fall of 1940. However, as the threat waned and additional photointerpreters were trained and came on line, the 36-hour battle rhythm (12 hours on, 12 off, and 12 preparing to go back on shift) became the norm for the rest of the war.⁸

When the Aircraft Operating Company came under Air Ministry control on 1 April 1940, its 37 staff members were drafted into the RAF and amalgamated with AI.1.(h), the small Air Ministry unit which had been formed in March 1938 to do detailed photointerpretation work. The new unit was named the Photographic Interpretation Unit (PIU). This direct predecessor of the CIU was quartered at RAF Wembley with an authorized strength of 189 and an actual strength of 133. It was briefly under the direct operational control of Air Ministry A.I.8, but once France fell, and the threat of invasion became real, control was vested in RAF Coastal Command on 11 July 1940, a decision that made sense at the time but would occasion a bitter feud over operational control of the CIU between Coastal and Bomber Commands as the latter's operations eclipsed those of the former by mid-1941. Ultimately, the Air Ministry solved this problem by taking direct operational control once again in the summer of 1943.⁹

⁸ AIR 34/89, "Report on the Wartime Activities of the Aircraft Operating Company Ltd. Covering the Period 3rd September 1939 to 31st January 1941 Including the Work of the Photographic Interpretation Unit (P.I.U.)," 18 February 1941, 1-2.

⁹ These intra-service issues receive detailed attention later in this chapter.

Just before this realignment occurred, Squadron Leader P. J. A. Riddell, Officer in Charge of the Photographic Interpretation Section at HQ Bomber Command, reported for duty as the senior interpreter at the PIU. Riddell's arrival in June 1940 marked the start of key improvements in PIU capabilities based largely on a proposal he submitted recommending changes to the unit, all of which the PIU's commander, Wing Commander H. Hemming, and the Air Ministry, approved and put in place. They credited Riddell's "comprehensive knowledge of interpretation and of Service practice and...his untiring and brilliant efforts" in developing a new PIU process "which appears to give satisfaction to all those Service Departments making use of P.I.U."¹⁰ Riddell's brilliant work, now and throughout the war, was of vital importance to the Allied BDA effort.

Riddell began his paper with a reminder that centralized control of the photoreconnaissance and photointerpretation processes was indispensable given the scarcity of high-performance aircraft and skilled interpreters. "It is the agreed intention of all concerned," he continued, "with the present exception of Bomber Command, that all photographic interpretation shall be done at a central unit."¹¹ To bring Bomber Command into the fold along with all other RAF commands as well as the Admiralty and the War Office, he thus proposed that the Air Ministry direct the amalgamation of Bomber Command's Photointerpretation Section with the PIU, a move that occurred, after a hard-fought battle, in March 1941.¹² Riddell also pushed for continuation of the

¹⁰ AIR 34/89, "Report on the Wartime Activities of the Aircraft Operating Company Ltd. Covering the Period 3rd September 1939 to 31st January 1941 Including the Work of the Photographic Interpretation Unit (P.I.U.)," 18 February 1941, 4-5.

¹¹ AIR 34/89, Memo, Squadron Leader P. J. A. Riddell, "P. I. U. Expansion," 11 July 1940, 1, 5.

¹² Despite this loss of its dedicated photointerpretation section, HQ Bomber Command retained three interpreters to provide specialized damage assessments and other reports for the head of Bomber Command and his staff. In addition, Bomber Command received a PIU liaison officer who came to play a vital

24-hour system of operations described earlier, and for the 1st-, 2nd-, and 3rd-phase interpretation process that came to define CIU operations. He proposed the establishment of PIU liaison officer positions at HQ Bomber and Coastal Commands, and at the Admiralty and War Office. In addition, Riddell spearheaded a change in procedure whereby the photographic developers at PIU printed enough copies of each photograph for plotting, interpretation, and other activities to occur simultaneously in the various PIU sections, rather than sequentially, resulting in a huge increase in the unit's efficiency. To increase efficiency even further, he introduced to the PIU a standardized system he had perfected at HQ Bomber Command for annotating and labeling prints prior to dissemination and filing. This system stayed in force until the end of the war. Finally, he received permission to engage in a major public-relations effort in which he and other PIU officers traveled to other commands and organizations and made them familiar with the broad and growing range of services available at the PIU. This campaign proved highly successful, with Riddell reminding his audiences that the PIU maximized "the time-worn principles of Economy of Effort and Concentration of Force."¹³

The PIU quickly developed an effective photointerpretation capability as a result of Riddell's efforts. Although the unit was initially regarded as something of an oddity due to its many civilians-turned-airmen, including a rapidly growing contingent of Women's Auxiliary Air Force (WAAF) personnel, outside observers soon came to value the PIU's pioneering role and the exceptionally important and high-quality products it turned out.

coordinating role between the two organizations. See AIR 34/89, "Some Notes Re: P.I.U. and Danesfield," Appendix C, 18 February 1941.

¹³ AIR 34/89, 2803-2808, Memo, Squadron Leader Riddell, "P. I. U. Expansion," 11 July 1940, 3-5.

The photointerpreters' meticulous work and growing expertise made their annotated photographs and assessments highly valued from the outset. As a wartime history noted,

All reports issued by the Unit represent the collective experience of its personnel backed by a comprehensive library of information and a most rigid system of cross-checking. No report represents the opinion of one individual.¹⁴

It concluded with reminder that the PIU served many customers, providing interpretation reports for targeting, BDA, and to gain a detailed knowledge of virtually every enemy economic and military installation,

in order that a watch may be kept over activity on the enemy's coastline, in his ports and also on his aerodromes and back areas, including his manufacturing centres. This means that personnel having either a broad knowledge of the economic life of Germany and German occupied territories are required, as well as specialists having a particular knowledge of oil refineries, factories, radio stations etc. in addition to other personnel who may be employed as specialists on flak, aircraft types, etc.¹⁵

In the meantime, PIU personnel continued developing procedures to maximize the unit's efficiency and effectiveness. As the PIU's first instruction stated,

It is the function of this Unit to provide information from Air photographs received from all sources, with the minimum of delay. Reports are to be teleprinted, and followed up by Interpretation Reports by 1st and 2nd Phase Section, and Detailed Reports by 3rd Phase Sections...It is, therefore, the intention of this organisation to provide ALL information from photographs obtained by any one Sortie within 12 hours of the aircraft landing or of the prints arriving at Heston from Detached Flights.¹⁶

The practice of sending key results of 1st phase interpretation by teleprinter, within two hours of receipt of photographs, to interested parties persisted throughout the war and

¹⁴ AIR 34/89, "Report on the Wartime Activities of the Aircraft Operating Company Ltd. Covering the Period 3rd September 1939 to 31st January 1941 Including the Work of the Photographic Interpretation Unit (P.I.U.)," 18 February 1941, 10-11.

¹⁵ Ibid.

¹⁶ AIR 34/83, "P.I.U. Internal Procedure," 1 August 1940, 1.

gave senior airmen intelligence they were able to use to task additional sorties against a given target within hours or at most a day, a process that became common after 1943.

The purpose of 2nd-phase interpretation, completed within 12 hours of receipt of photographs, was to verify the accuracy of 1st-phase reports while conducting a more detailed study of photos and providing additional insights in supplementary reports. Of key importance here was a requirement to have 2nd-phase reports ready for the courier runs to London at 0600 and 1800 hours each day. The use of teleprinter and truck to deliver actionable intelligence as rapidly as possible became a trademark of Allied air intelligence and was most evident in the production and distribution of BDA reports.¹⁷

Once 2nd-phase reports were on their way, the specialized interpretation shops, including Hamshaw Thomas's D (Industrial) Section and K (Damage Assessment) Sections, as well as those specializing in railroads, inland waterways, airfields, aircraft, ports, naval vessels, air defense installations, supply dumps, and several other categories, went to work on 3rd-phase reports. These often took two weeks or more to produce and were increasingly the result of collaborative efforts with MEW, the Railroad Research Service, the Admiralty, the War Office, and other economic and military intelligence organizations.¹⁸ These interagency efforts yielded an increasingly comprehensive understanding of every major target system in the Reich and German-controlled Europe, including the French and German transportation systems and the German oil industry, all of which would come under heavy Allied air attack in 1944-45. The astonishing thing about this development is the fact that the British carried it through *before* they had any

¹⁷ Ibid., 4.

¹⁸ Ibid., 6.

kind of credible bomber force. Clearly, there was agreement among British civilian and military leaders that they would *eventually* have the bomber assets to attack these targets effectively, and this faith in future capabilities as yet barely glimpsed proved one of the more important and positive developments in an otherwise bleak landscape.

Responsibility for tracking the progress of all these efforts lay with the Duty Officer and Duty Clerk, and their administrative assistants, who logged in all requests for reconnaissance and all photographs received from the PDU (later the PRUs), distributed the photographs to appropriate sections for interpretation, prodded section chiefs when work was not completed in a timely fashion, and worked with the Despatch Section to ensure all completed work was delivered to the proper customers on time. They also ensured that all photographs received from the PDU went first to the Print Library, where technicians filed all prints received, made cover plots on large-scale charts showing the entire area covered by each sortie's photos, and provided the prints, maps, and reports made by the Intelligence Section to internal and external customers. A new and vital asset, unique in the annals of warfare—a centralized photointelligence capability—had emerged. It would be tested and found worthy during five more years of war.¹⁹

As these developments unfolded at the PIU, Sidney Cotton, who had deployed to the Continent to lead RAF photoreconnaissance efforts in support of the British Expeditionary Force in France, ran afoul of the Air Ministry's senior leadership and was fired upon his return to Great Britain on 17 June 1940.²⁰ The reasons for this abrupt dismissal are not entirely clear but were likely due to three related problems. The first

¹⁹ Ibid., 7-9.

²⁰ For a copy of the letter firing Cotton, see Babington Smith, *Evidence in Camera*, 48-49.

was Cotton's reputation as a maverick who went around the chain of command whenever it suited him to get things done. Air Vice Marshal Fred Inglis, the Air Ministry's Assistant Chief of Air Staff, Intelligence—ACAS(I)—had stated in a memo to Sir Archibald Sinclair, the Secretary of State for Air, that "Cotton's methods will never work in with R.A.F. procedure, and a blow-up is bound to occur sooner or later."²¹ Inglis followed this with a proposal for making the PDU and PIU regular RAF units in every sense of the word. "Under my proposals," he said, "I think he [Cotton] could be kept to the point and would not upset or try to control the rest of the Air Force." A second and related problem, which Inglis also noted, was the constant irritation Cotton's freelancing caused the Air Staff, the RAF as a whole, and the Admiralty, all of whom were tired of dealing with Cotton and resented his methods and his inability to carry off the entire operation—photoreconnaissance and photointerpretation—on his own. Inglis sought to bring the PIU under Air Ministry control, which in fact occurred for a brief period, while leaving Cotton in control of flying operations at the PDU.²² Third—and this appears to have been the final straw—was Cotton's loss of nearly all his unit's ground equipment during the retreat from France, which appears to have been a result of Cotton's once again ignoring Air Ministry orders until too late.²³ The end result of these problems was Cotton's replacement by Wing Commander G. W. Tuttle, Cotton's deputy, who was a regular RAF officer. As Inglis had recommended, command of the two halves of the reconnaissance and interpretation effort was given to two officers to allow for effective

²¹ AIR 40/1495, Memo, Inglis to Sinclair, 4 March 1940.

²² AIR 40/1495, "Proposals for the smooth running and most efficient working of the 'Cotton outfit,'" 4 March 1940, 1-2.

²³ Powys-Lybbe, *The Eye of Intelligence*, 30.

span of control, with Tuttle commanding only the PDU (the photographic reconnaissance unit) and Wing Commander Hemming in charge of photointerpretation efforts at the PIU.

Consequently, while Hemming and Riddell pushed forward the concept and operational capabilities of the PIU, Tuttle, now in command of the PDU, worked to meet the requirements levied by the Air Ministry and the Admiralty. His few aircraft (at first only four, but increasing to 16 by spring 1941) and their pilots thus had to fly missions to produce aerial photographs for targeting purposes as the Air Ministry and Bomber Command intelligence organizations, along with MEW, called for regular reconnaissance of all large cities in Germany—as often as once a week—to develop comprehensive target-materials folders. This task took on added urgency once Bomber Command began sustained bombing of the Reich during fall 1940. Among the most important of these was the first cover of the entire Ruhr, obtained by a *single* Spitfire sortie on 2 March 1940 and still in use for target materials in 1944.²⁴ In addition, Bomber Command expected PDU pilots to fly an increasing number of post-strike BDA sorties as the number of Bomber Command operational missions increased in summer and fall 1940. Tuttle's pilots also flew constant collection missions for their most important customers at this time, Coastal Command and the Admiralty, who were responsible for keeping track of German preparations for a possible invasion of the British Isles. This involved conducting photoreconnaissance of all German-controlled ports twice a week, and, during

²⁴ Ibid., 23. See also AIR 40/1816, *Photographic Intelligence during the European War*, 30 June 1945, 14, which noted that "As extensive areas can be covered in one strategic sortie at the rate of two square miles of territory per exposure, each flight can produce photographs of three thousand square miles of enemy territory." As the number of reconnaissance aircraft increased in 1941 and 1942, the British very quickly amassed comprehensive photographic cover of virtually every square foot of Europe. If the Germans built anything, moved anything, or tried to hide anything, the British (and later the Americans) almost invariably located it. This huge collection of photographs, and of the ability to take thousand of new ones every day, were of fundamental importance to the success of Allied targeting and BDA efforts later in the war.

the high point of the invasion threat, of key French and Belgian port cities on the English Channel *three times a day*. To maximize the effectiveness of these collection efforts, Tuttle gave all his reconnaissance missions primary and secondary objectives, which meant they almost always brought back photos of something of value to the German war effort and, therefore, to British intelligence.²⁵

A meeting at the Air Ministry on 2 October 1940 confirmed that the proper role of the PDU was to provide centralized tasking for photoreconnaissance missions and thereby replace the previous system in which each Service and—in the case of the RAF—each command had its own photoreconnaissance aircraft. The plan agreed upon was a continue the ongoing process of centralization within which the PDU flew reconnaissance missions as required for the various Services and commands, while at the same time evolving from squadron to group size, conducting all of its flying training in house, and designing specialized equipment for its aircraft and cameras. Bomber Command and Coastal Command disagreed on the need for a single photoreconnaissance group, due no doubt to the fact that Coastal Command received the lion's share of the PDU's missions to track German pre-invasion activity, while Bomber Command often had to go without BDA photos. Nonetheless, they agreed on the need for a centralized photointerpretation and photointelligence capability at the PIU. To oversee this process, the Air Ministry soon created a new position: the Assistant Director of Intelligence for Photography—ADI(Ph). The creation of ADI(Ph), who exercised policy and operational authority over the entire tasking and production process for photoreconnaissance and

²⁵ AFHRA 168.7026-2, Major D. W. Hutchison, Report No. BES-281, "One Week's Visit to the P.R.U. at Benson," 27 October 1941, 1-2.

photointerpretation from 1941 until the unit's replacement by the Joint Photographic Reconnaissance Committee in May 1944, proved crucial in the effort to centralize and make as effective and efficient as possible these key aspects of the BDA process.²⁶

These efforts to iron out the details of photographic reconnaissance operations continued at a meeting in February 1941 chaired by Air Vice Marshal Peck, the Assistant Chief of Air Staff, and attended by a number of key flying and intelligence officers, including Group Captain Laws, the Air Ministry's Deputy Director of Photography, Squadron Leader Riddell of the PIU, and Mr. Lawrence, a senior intelligence officer from MEW. These individuals all expressed a continuing commitment to the idea that British photoreconnaissance aircraft would have to operate at 30,000 to 40,000 feet of altitude to avoid German fighters and flak. However, they also recognized that the short (6") lenses on F24 cameras carried aboard Spitfire reconnaissance aircraft were incapable of providing 1:12,000-scale coverage at those altitudes.²⁷ Riddell emphasized that 1:12,000 was the smallest scale at which photointerpreters could conduct truly in-depth assessments of aerial photographs from those altitudes. Two key problems presented themselves here. The first was an as-yet unmet requirement for 30" and 40" camera

²⁶ AIR 14/597, Air Ministry, "Minutes of a Meeting held...to discuss the existing Photographic and Interpretation Organization and the Proposal to form a Photographic Reconnaissance Group," 2 October 1940.

²⁷ For an excellent discussion of photographic scale, see Stanley, *World War II Photo Intelligence*, 254, 270. Stanley noted that the scale 1:63,360 denotes one inch on the photo equal to a statute mile on the ground. Fractions of this can thus be calculated, with 1:15,840 meaning an inch on the map equal to $\frac{1}{4}$ mile. A larger denominator thus means a smaller scale. A 36-inch lens will collect images at a scale three times larger than a 12-inch lens at a given altitude. The basic formula is altitude divided by focal length (using the same unit of measure—feet or inches—for both). Thus, at 20,000 feet a 12-inch lens will provide 1:20,000 scale, while a six-inch lens will provide 1:40,000 coverage. Thus, once a photointerpreter knew a photograph's scale, he or she could the size of any object on the ground. Frames from a 12-inch lens would cover 2.8 miles on a side, and those from a six-inch lens would cover 5.7 miles on a side. These computations allowed interpreters to ensure they had the right lenses for each specific objective and coverage requirement. It also allowed them to determine whether specific objects could be analyzed, identified, or even seen. Film grain size also played a role here. Any magnification over 10x would bring out film grain and make photos very difficult to read.

lenses, which Laws said would not be available until summer. Neither of these lenses would fit in the Spitfire, which could carry at most a 20" lens that provided good—but not great—detail. Consequently, this meant the Mosquito reconnaissance aircraft, then on the drawing boards, would be indispensable for obtaining the most detailed possible post-strike cover to assess the effects of bombing raids. Attendees also recognized the growing importance of night photography for BDA purposes.²⁸

The list of attendees at this meeting provides a useful reminder that the Air Ministry, PDU, and PIU excelled at hiring the best photographic and photointerpretation talent in the United Kingdom. As a result of their efforts, a steady stream of experts, most of them World War I veterans, arrived at the PDU and PIU during 1940 and, collectively, exerted a highly positive influence on the development of targeting and BDA capabilities. Wing Commander Hemming himself had been involved in aerial photography during the Great War. In addition, Flight Lieutenant H. Hamshaw Thomas, a distinguished World War I photointerpreter who worked as a botanist at Cambridge University between the wars, arrived at the PIU looking for work in fall 1940. Once there, he rewrote the Air Ministry manual on aerial photography and then took charge of the PIU's new D (Industry) Section, which ultimately produced thousands of reports on German industrial facilities, including synthetic oil plants and crude oil refineries. The same process occurred throughout the intelligence community, with Wing Commander (later Group Captain) F. C. V. Laws putting on the uniform once again to become the Air Ministry's Deputy Director of Photography. The first wartime course for RAF photographic officers at

²⁸ AIR 14/1216, Air Ministry, Group Captain F. C. V. Laws, "Minutes of a meeting held in the Air Council Room at 1500 hours on Thursday, 13th February 1941 to discuss the use of Air Photographs for Assessment of Bomb Damage," 1-2, 4.

Farnborough, December 1939 – January 1940, featured 10 officers in their 40s or older, all with photointelligence experience in the Great War or during the interwar period. The RAF leadership, to its credit, recognized that such talent and experience were rare and should be employed in jobs where they would yield the highest returns.²⁹

These veterans of the Great War and their younger comrades did not have long to wait before the exigencies of war put their photointerpretation skills to the test, first in support of RAF and army operations in France, and then during Bomber Command's first two strategic bombing campaigns, the first a small-scale and unsuccessful effort against oil and railway targets in the Ruhr in the opening stages of the German attack on France and the Low Countries, and the second against German barges and port facilities along the Channel coast after the fall of France. In the case of attacks against the Ruhr, all were made at night, and, as the few available PIU and Bomber Command damage assessments confirmed, most missed their targets. Only a few such raids were attempted, however, because the disaster in France forced Bomber Command into a ground-support role, which failed to stem the German advance and led to very high losses among British bombers, often over half of those in each mission. The upshot of these high casualties was a bomber force even less capable of achieving any objectives set for it, and by this time Air Chief Marshal Sir Charles Portal, now in charge of Bomber Command, had *three* directives: one to attack German oil production, another to go after German airfields and aircraft production, and, once the threat of invasion became serious, a third to attack German port facilities and especially barge traffic in the Channel ports. Portal

²⁹ Babington Smith, *Evidence in Camera*, 26, 58, photograph facing 118.

received the latter directive on 4 July 1940, and it proved the one bright ray of success in an otherwise stormy operational performance.³⁰

British bombers attacking barges in the Channel ports for the most part made night attacks, although there were a few small day raids with fighter escort. Both their night and daylight bombing accuracy proved reasonably good, in large measure because the ports, given their locations along the Channel coast and their distinctive landmarks such as docks and breakwaters, proved easy to locate. In fact, British bombing did serious damage to German barges, a fact substantiated at the time by PIU damage assessments. Barge traffic began building up in August and September 1940, by which time there were as many as 250 barges in the larger ports along the English Channel.³¹ By 18 September, PIU photointerpreters counted 1,004 barges at the five major Channel ports between Flushing and Boulogne. Bomber Command began going after the barges on the night of 8-9 September, flying over 2,900 sorties from the first attacks by 92 bombers on the night of 7-8 September to the last by 93 bombers on the night of 12-13 October.³² Between 18 and 27 September, RAF bombers made nine heavy attacks against Boulogne, dropping 143 tons of bombs. Post-strike cover showed that the number of barges visible at the port had decreased from 220 to approximately 190, the rest having been sunk or damaged. PIU interpreters noted that there was no increase in barges at neighboring ports,

³⁰ Webster and Frankland, *Strategic Air Offensive*, Vol. I, 144-148.

³¹ AIR 34/90, CIU, Interpretation Report No.A.55, 9 December 1941, 1-2. This report, published nearly a year after the British campaign against invasion barges ended, was both a historical record and an indication of the potential of British bombers to sink barges should the Germans attempt to concentrate them again for an invasion attempt. The report's timing is significant given the uncertainty that the Soviet Union would be able to survive the ongoing German invasion, and therefore the potential that a German invasion of the British Isles might again become a serious threat in spring and summer 1942. It is also important to note that the report was based on a compilation of reports and aerial photographs produced in 1940, while the bombing campaign against barge traffic was ongoing.

³² Middlebrook and Everitt, *Bomber Command War Diaries*, 80-91.

indicating that the 30 missing barges had in fact been sunk. A number of others were also damaged and in dry-dock or simply beached. An even more effective series of raids on Calais, between 17 September and 10 October, which delivered 196 tons of bombs, sank nearly 100 barges and damaged many more. Photographs showed that barges there had been packed gunwale to gunwale, making easy work for the bomber crews. Strike photographs taken by bombers as raids were ongoing also proved very useful in determining the effects of the bombing.³³ Together with post-strike photographs taken by PDU Spitfires, they confirmed that by 21 September British bombers had already sunk over 10 percent of the barges assembled for the invasion.³⁴ British attacks continued in force until April 1941, by which time nearly all of the remaining barges had moved to ports in Belgium and the Netherlands, where they no longer posed as great a threat. In fact, by February 1941 there were 650 barges in Antwerp and another 650 in Rotterdam. Further British attacks, though not as frequent, forced yet another dispersal up the canals and rivers of the Low Countries, where barges were moored in small groups and camouflaged to reduce the effects of British bombing. During the campaign, PIU interpreters had also located several shipyards in Holland where the Germans were modifying barges to serve as Tank Landing Craft and other heavy-equipment carriers. Needless to say, these shipyards also received attention from British bombers.³⁵

The British bombing campaign against German invasion barges was one of the few operational bright spots in the British war effort during the fall of 1940. Accurate British night bombing, and poor German security measures such as packing their barges close

³³ AIR 34/90, CIU, Interpretation Report No.A.55, 9 December 1941, 3-6.

³⁴ Hinsley et. al., *British Intelligence*, Vol. 1, 189.

³⁵ AIR 34/90, CIU, Interpretation Report No.A.55, 9 December 1941, 7.

together, led to serious losses of landing craft and in fact forced the Germans to disperse the remainder of their barge fleet much more extensively than they would have liked. The PIU interpretation report covering these developments was thus accurate in its assessments of the effects and, more importantly, the effectiveness of British bombing, and also prescient and timely in its recognition that, should the German drive in the East succeed, British bombers might be called upon to wage a second campaign against German barge traffic in 1942 and could in fact do so quite well.

As the campaign against invasion barge traffic continued, so too did British bombing of aircraft and oil targets. While the former received progressively less effort as the Battle of Britain wound down and resulted in a clear British victory, the latter once again took center stage and soon became the primary focus of British bombing efforts.³⁶ While this first oil offensive will receive a good deal of attention shortly, we must first return to developments at the PDU and PIU, both of which continued to evolve throughout these early British bombing efforts.

During January 1941, as the first oil offensive began, the PDU and PIU continued their rapid evolution resulting not only in improved capabilities, but also in the adoption of the titles they would carry for the rest of the war: PRUs and CIU. First-phase interpretation, which had previously been completed at Wembley, was now moved to the three photoreconnaissance flights at Benson, Wick and St. Eval to keep damage assessment and reconnaissance reports moving to the CIU as quickly as possible for 2nd-phase interpretation. During this period, the drawing and modeling sections began using aerial photos annotated by the Wild Stereo Plotter to produce exceptionally accurate

³⁶ For a look at these developments, see Webster and Frankland, *Strategic Air Offensive*, Vol. I, 151-153.

plans, drawings, and scale models of an increasing number of German industrial and military installations. These new products ultimately played major roles in the targeting and BDA processes by allowing aircrews to improve their recognition skills while providing detailed diagrams of industrial facilities showing both cumulative damage and that caused by the most recent raid. The CIU also fielded an Intelligence Liaison Section comprised of expert intelligence officers and photointerpreters from all three Services who assisted their counterparts in the various work sections by providing background intelligence necessary to analyze aerial photographs and produce accurate damage assessments. Perhaps most important, however, was the Instructional Section set up to train new photointerpreters in advanced interpretation *before* their assignment to various CIU work sections. Every new photointerpreter had to complete a rigorous three-month course, become thoroughly familiar with a Photointerpretation Handbook developed by CIU personnel and updated regularly, and pass a demanding final exam. The instructors were all experienced photointerpreters with a good bit of operational experience, which meant students received training from experts in each specific area of interest, whether railroads and inland waterways or oil plants and refineries.³⁷

During this period, the CIU also changed locations in the aftermath of a German bomb hit on the facilities at Wembley, which destroyed a large quantity of equipment and photos. Several photointerpreters were also killed or wounded. To make matters even more complex, PRU1 was already in the process of moving to RAF Benson. Therefore, to keep the two units located adjacent to one another, the CIU began its move to RAF

³⁷ AIR 34/84, CIU, "Formation of Central Interpretation Unit," 7 January 1941, 1-3; AIR 34/89, CIU, "Work Undertaken By Photographic Interpretation Unit in Connection with the Interpretation of Air Photographs," 18 February 1941, 1-3.

Medmenham on 13 January 1941 and would stay there after completion of the move in April 1941, with satellite bases at RAF Pinetree and Nuneham Common, for the duration. Fortunately, Medmenham was a large facility and could house the rapidly-growing CIU, which would soon have over 400 personnel assigned.³⁸ This huge increase in personnel was a response to the insatiable demand for annotated aerial photographs and associated interpretation reports at all the major military headquarters and civilian economic intelligence agencies. By this time, the PRUs were flying at least 17 sorties per day, each of which carried F24 cameras capable of taking 125 photographs for interpretation, meaning the interpreters had no less than 2,125 prints *per day* to assess by this time.³⁹ While most of these prints provided baseline knowledge of German industrial and military facilities for targeting purposes, an increasing number were BDA photographs.⁴⁰

In March 1941, Hemming and Riddell called once again for the incorporation of Bomber Command photointerpreters into CIU's D (Industrial) and K (Damage Assessment) Sections, a move the Air Ministry approved and one made the following month despite Bomber Command protests. They also proposed that a new photointerpreter's apprenticeship after completion of the PI course would last an entire year, an indication of the very high professional standards CIU leaders had for their subordinates. To maximize the effectiveness and efficiency of collection and analysis,

³⁸ Manpower levels increased from 68 personnel in August 1940, to 169 in January 1941, and then to 402 by summer 1941. See AIR 34/83, Aircraft Operating Company and PIU Roster, and AIR 34/89, "Some Notes Re: P.I.U. and Danesfield," Appendix C, 18 February 1941.

³⁹ For details on the F24 camera carried on British Spitfire reconnaissance aircraft, including film capacity, see Stanley, *World War II Photointelligence*, 167.

⁴⁰ AIR 34/89, CIU, "Report on the Wartime Activities of the Aircraft Operating Company Ltd. Covering the Period 3rd September 1939 to 31st January 1941 Including the Work of the Photographic Interpretation Unit (P.I.U.)," 18 February 1941, 6-7.

Tuttle and Riddell also called for the immediate formation of a Controlling Section, composed of a field-grade officer from each Service, to ensure all reconnaissance requirements received equal and expeditious treatment. This, too, the Air Ministry approved, and the resulting incorporation of army and navy officers into the Duty Section improved the CIU's efficiency tremendously and prefigured the formation of the Joint Photographic Reconnaissance Center, a requirements-and-collection management unit that directed Allied photoreconnaissance and photointerpretation operations from May 1944 to VE Day. Finally, Tuttle and Riddell pushed hard for Air Ministry operational control of the CIU and PRUs, rather than their continued subordination to Coastal Command. With the invasion threat less severe and the bombing offensive against Germany picking up steam, they believed only the Air Ministry Directorate of Intelligence could be an impartial master. "It is proposed," they said,

that Interpretation shall become a part of intelligence, and shall take its place as the hand-maiden of the latter. Interpretation will never be of full use until it is part of the intelligence organization which it serves and by which, by direct contact, it is supplied with information...Control of this organization would be vested in the Air Ministry under the Directorate of Intelligence...Until this, or some other similar scheme is fulfilled, a large amount of information not available from interpretation, and the vast amount yet to be tapped, will not be made available to the original recipients in the shortest possible time, and in the form required by the latter.⁴¹

Although a bitter fight with Coastal Command lay ahead, the Air Ministry sided with Tuttle and Riddell and brought the CIU and PRUs back under direct Air Staff operational control in the summer of 1943, which proved to be a crucially important development.

By August 1941, the CIU had assumed the basic outlines it would maintain until the end of the war. It had 14 total Sections, the most important of which were the 1st-, 2nd-,

⁴¹ AIR 34/83, CIU, "Interpretation of Air Photographs," 9 March 1941, 6.

and 3rd-Phase Interpretation Sections, where the heart of the unit's mission was accomplished. First-phase interpretation was now carried out by CIU photointerpreters assigned to the three PRU flights at Benson, St. Eval, and Wick. They sent their reports by teletype and courier to all interested parties, including CIU K (Damage) Section, which reviewed the first-phase reports and then forwarded them to all customers on their distribution lists (and by 1944 there were over 540 British and American customers for damage assessments) as Immediate Interpretation Reports. Photointerpreters involved in 2nd-phase interpretation were required to examine in detail as many as 50 prints in a single 12-hour shift. Once they completed their work, annotated prints and reports went to the specialists in the various 3rd-phase sections, including D (Industry) and K (Damage Assessment) Sections, which then used them to develop detailed reports, usually in conjunction with MEW and other intelligence organizations.⁴² In fact, CIU instructions stated that "Third Phase Officers have constantly to examine ground features in this country [UK] similar to those they are reporting on in enemy occupied territory. They have, therefore, to be constantly detached for special investigations..."⁴³ They were, in other words, constantly visiting British factories, oil plants (there were actually several synthetic oil plants and crude oil refineries in Great Britain during this period), and other facilities to determine exactly how they functioned. These visits and discussions with plant managers and engineers gave British photointerpreters and other air intelligence

⁴² AIR 34/83, CIU, "Royal Air Force Station, Medmenham, Organisation and Sections," 6 June 1941, 1-4; AIR 40/1172, CIU, "Royal Air Force Station Medmenham: Organization and Sections," 17 August 1941, 1-2. Other 3rd-phase sections were those focused on the German Navy, Army, Aircraft, Aerodromes, Camouflage and Decoys, Communications (now known as "Transportation," including railroads, inland waterways, and roads), Wireless, and Flak.

⁴³ AIR 40/1172, CIU, "Royal Air Force Station Medmenham: Organization and Sections," 17 August 1941, 2.

personnel a deep knowledge of the German war economy and its key vulnerabilities, which proved a great boon to targeting and BDA efforts.

Several of these changes grew out of a key meeting held at the Air Ministry in February 1941 to determine the most effective use of aerial photographs for assessing bomb damage. Air Vice Marshal Peck, the Assistant Chief of Air Staff, Chaired the meeting, and Group Captain Laws, the Air Ministry's Deputy Director of Photography, played a key role, as did Squadron Leader Riddell of the CIU and Mr. Lawrence from MEW. All attendees agreed that "experts of M.E.W. should be available to C.I.U. to give advice on how a factory works and to state what effect the damage had on the works as a whole."⁴⁴ This meant CIU interpreters and MEW economic intelligence experts would have to work more closely with one another, and with plant managers, engineers, and other experts in various industries, to produce 3rd-phase BDA reports. All agreed that while the CIU had to provide damage assessment reports for individual raids, MEW should look at all BDA reports over a longer period of time, and in the aggregate, to determine the longer-term effects and effectiveness of bombing operations on the German war economy and the morale of the German people. And although RE8 did not come into existence until 1942, it too would soon play a key role in this process by providing detailed BDA and MEA reports as well as assessments of post-strike reconstruction and repair at key German industrial and military installations.⁴⁵

The CIU office responsible for this interagency coordination of BDA reports was K (Damage Assessment) Section, formed as part of the original PIU in 1940 and augmented

⁴⁴ AIR 14/1216, Air Ministry, Group Captain F. C. V. Laws, "Minutes of a meeting held in the Air Council Room at 1500 hours on Thursday, 13th February 1941 to discuss the use of Air Photographs for Assessment of Bomb Damage," 1-2, 4.

⁴⁵ Ibid., 4.

in the late summer of 1941 with the arrival of eight photointerpreters from the HQ Bomber Command Damage Section. The interpreters of K Section were responsible for assessing the damage done by each Bomber Command raid. The principal assessments they produced included Immediate Reports, which were due to all customers within 24 hours after receipt of photographs, with usual completion time being 6-12 hours, and Detailed Reports, which usually followed Immediate Reports by 24 to 48 hours. Once it reached maturity in 1942, K Section was subdivided into four watches of 6-8 people each who produced all Immediate Interpretation Reports, plus a supervision and specialist group comprised of senior and highly experienced interpreters who prepared all Detailed Interpretation Reports and a variety of Special Reports. The members of K Section also maintained Damage Dossiers, each of which contained all the damage reports produced for a given target, and Attack Files, which contained a running ledger of all attacks carried out against a given target to include date, number of aircraft involved, bomb tonnage dropped, and a brief synopsis of results.⁴⁶

Immediate Interpretation Reports were based on a comparison of pre-raid and post-raid photographs and consisted of a general statement on the distribution and severity of the damage followed by brief details on the condition of the more significant elements of the target. They also included photographs showing the principal points of damage. The printed report followed a teleprinter version highlighting key damage done in a raid, which was sent to the organizations most concerned. A supplement to the Immediate Interpretation Report might also be sent within the next few days if new

⁴⁶ AIR 34/85, ACIU, "Brief History of 'K' Section," 1944, 1; AIR 34/85, 2684-2687, "Operational Record of 'K' Section (Damage Assessment)," ACIU, 1945, 1-4.

photoreconnaissance cover or other intelligence brought to light additional details regarding damage to the target.⁴⁷

Detailed Interpretation Reports were based on a much more thorough examination of the target area and included a general statement summarizing the effects of an attack followed by details. For detailed assessments of urban areas, which by summer 1941 were becoming more frequent, damage was illustrated by a colored graphic depicting areas of the city previously destroyed (shown in blue) and areas destroyed in the most recent raid (shown in red). In addition, detailed reports on city raids contained listings of the individual industrial facilities damaged and details on the extent and nature of the damage. This level of detail required that photointerpreters conduct a building-by-building examination of all structures within the area damaged by a given raid. Detailed Interpretation Reports also acted as a basis for a variety of Special Reports issued by K Section, often in conjunction with MEW and RE8, on post-raid reconstruction, cumulative damage, and bomb performance.⁴⁸

Because these reports had a great deal to say about the efficacy of British bombing, they also had a significant influence on the evolution of bombing policy, doctrine, and strategy. Although the small-scale and sporadic raids, small bombs employed prior to 1942 (250-lb. munitions were the norm until spring 1941), and very poor accuracy of raids early in the war made K Section's job rather tedious and unrewarding, interpreters nevertheless gained valuable experience and were ready, when the British bombing effort expanded dramatically in 1942, to meet the challenges brought on by the city-bombing

⁴⁷ AIR 34/85, ACIU, "Operational Record of "K" Section (Damage Assessment)," 1945, 2-3.

⁴⁸ Ibid., 3-4.

campaigns of 1942-44. The addition of several American photointerpreters in 1942 also helped to ease the personnel tempo associated with this expanded bombing offensive. The most important development regarding K Section, however, was its increasingly close interaction with MEW and several other civilian intelligence agencies involved in the evolving BDA process. As these relationships developed and strengthened in the period between 1939 and 1941, they resulted in an increasingly mature and capable organizational framework within which BDA reports were coordinated, produced, and disseminated rapidly and with significant operational effects.⁴⁹

6.3 Organizational Innovation: Ties between Air Ministry, MEW, and CIU

In the opening months of the war, there was a good bit of confusion and acrimony in the BDA process. Because the PIU was not yet up and running, the PDU had too few aircraft to conduct more than a few missions per week, and only a handful of RAF bombers had strike cameras installed, the Air Ministry had to rely on Bomber Command's Blenheim reconnaissance aircraft for BDA reports. This proved impossible given the Blenheim's vulnerability to German fighters. Consequently, the Air Ministry often had to depend on the same kinds of unreliable sources air intelligence officers used during the Great War, namely, agent reports and newspaper articles. In addition, MEW, which in fact had statutory authority to conduct BDA for the purposes of assessing the economic impacts of bombing on the Reich, also began producing reports once the war started. These Industrial Damage Reports relied on the same kinds of sources but tended to be more conservative than the Air Ministry's reports. In both cases, however, they tended to be highly inaccurate. To make matters worse, there was almost no

⁴⁹ AIR 34/85, ACIU, "Brief History of 'K' Section," 1944.

communication between these two BDA producers in the first months of the war, leading to divergent conclusions and duplication of effort.⁵⁰

By the time the RAF engaged in its first concerted bombing campaigns, against the Ruhr and then against German barge concentrations in the Channel Ports, the PDU and PIU had developed to the point where pre-attack and post-strike aerial photographs and relatively comprehensive damage assessments, were gradually becoming the norm. In fact, by August 1940, 20 Spitfires were in service with the PDU, giving the RAF an ability to provide post-strike BDA photos for a majority of Bomber Command's missions.⁵¹ Also fortuitous was a gradual willingness at the Air Ministry and MEW to seek cooperation rather than conflict. The result was an increasingly close and fruitful relationship in which MEW brought to bear its many economic intelligence sources and, in cooperation with the PIU and its increasingly accurate reports, began producing 3rd-phase BDA reports that looked at the overall effects and effectiveness of British bombing. The fact that the relationship matured and the mutual respect deepened in the crucial period 1940-41 was absolutely essential for BDA successes in 1944-45.

The process seems to have had its start in a recognition among Air Staff officers that they could not go it alone. The result was a new Air Ministry office, A.I.3(B), in April 1940 (renamed A.I.3(c)2 in November 1942), charged with tracking the results of bomber attacks on land and naval targets as well as the effects of sea and river mining operations. Despite the fact that A.I.3(B) initially produced Raid Assessment Summaries that were initially often in conflict with MEW Industrial Damage Reports, the officers of A.I.3(B)

⁵⁰ Hinsley et al., *British Intelligence*, Vol. 1, 102; Webster and Frankland, *Strategic Air Offensive*, Vol. I, 267.

⁵¹ AIR 40/1816, Air Ministry, *Photographic Intelligence during the European War*, 30 June 1945, 1.

soon realized that competing with MEW was both impossible and inappropriate given MEW's charter to provide all assessments, including BDA reports, relating to the German economy. At the same time, PIU began producing the Air Ministry's BDA reports, which were of course shared with all interested parties, including MEW. And although the Air Ministry continued to produce Raid Assessment Summaries until the end of the war, they became in effect "executive summaries" of the entire bombing effort for senior civilian and military leaders. These general overviews lacked anything approaching the detail contained in MEW and PIU BDA reports (from which they drew most of their content) and were therefore effectively not in competition with them.⁵²

In the meantime, officers working in A.I.3(B) evidently realized that it was in everyone's best interests if they worked with their MEW counterparts not only to deconflict the tasks they performed, but also the products they turned out. This resulted in the creation of the German Bomb Target Information Committee, chaired by A.I.3(B) and including representatives from the Air Ministry Plans and Intelligence Directorates, and, most significantly, MEW. This marked the crucial point of departure for what would soon become a very close working relationship. The committee acted as a forum for sharing all BDA data, whether published or unpublished; agreeing on an appropriate division of labor between PIU and MEW for the production of future BDA reports; and determining the appropriate content of each organization's reports. Most importantly, it brought intelligence analysts together, allowing them to build professional relationships. By 1941, the cooperation vacuum was being replaced by a tangible framework in which

⁵² AIR 34/85, Air Ministry, "The Work of A.I.3(c)2," 20 July 1945, 1, 8-9.

each party knew its “lanes in the road” and stuck to them. This was a development of fundamental importance for the production of BDA reports and target materials.⁵³

During the first year after their agency’s creation in September 1939, MEW analysts had their hands full determining what exactly the now-defunct IIC had left them. At the same time, they began building an impressive repertoire of sources, which involved an intensive interaction with British businessmen, trade associations, and technicians who had knowledge of German industrial plant and equipment. This proved vitally important in providing details of the layout and machinery at each enemy industrial facility. The stability of German industry in the early years of the war allowed MEW analysts to develop a detailed understanding of each industry and then to track changes in them as the war progressed and the Germans decentralized many of their plants. These insights came not only from the sources just mentioned, but increasingly from reconnaissance cover, which corroborated other sources while laying open to MEW analysts virtually every German industrial installation of any note. As increasing numbers of refugees arrived in Great Britain in the wake of successive German conquests and volunteered to share their expertise and experiences as plant managers, engineers, chemists, oilmen, or common laborers, MEW analysts also built a strong knowledge of economic assets in occupied countries. This knowledge began to assume a mature state by the end of 1941. Although information on targets of economic and military importance in the Reich and occupied Europe was initially useful for building a baseline of knowledge about the German war economy, it soon became detailed enough to serve as target material and as

⁵³ Ibid.

reference material for assessing damage to various industrial facilities based on an understanding of their pre-attack productive capacities.⁵⁴

Colonel Vickers, Deputy Director of MEW and head of all substantive intelligence work, believed that the kind of information received by MEW, and the intelligence produced from it, required a very specialized kind of intelligence organization. Consequently, he structured MEW into several sections in which analysts studied specific industries or commodities and developed a deep knowledge of them over a period of years. They were therefore able to assess the value and specific meaning of new information, and then to change their assessments for their specific industry or commodities accordingly. Most of these analysts had worked, in the years leading to war, in the industries they covered for MEW.⁵⁵

MEW analysts proved remarkably adept at teasing useful intelligence from the most mundane and seemingly useless sources. Press articles from Germany, for instance, provided a wealth of information on raw materials shortages, advertisements for jobs at new plants, and products from various factories. Government representatives of occupied countries provided a wealth of insights and details relating to their countries' industrial infrastructures, building on the data provided by refugees. In fact, MEW's leadership had an agreement with the Ministry of Home Security allowing their analysts to conduct a thorough questioning of all refugees arriving in the United Kingdom. A similar agreement for the interrogation of German POWs existed with army interrogators, who asked a standard set of MEW-provided questions to determine if the prisoners had useful

⁵⁴ Spaatz Box 137, "Sources of Information Used by M.E.W.," no author listed, but probably produced by the Economic Warfare Division at the American Embassy in London in conjunction with MEW, 4 June 1942, 1-2.

⁵⁵ Ibid., 9.

economic knowledge. They often did, especially later in the war, as large numbers of skilled workers and technicians were drafted into the German army and then captured during Allied offensives in Italy and France. As individuals with important intelligence surfaced during the interrogation process, MEW personnel then interrogated them more carefully to obtain additional intelligence. At the same time, MEW representatives in neutral countries provided a steady stream of useful intelligence gleaned from neutral businessmen and government officials who had dealings with the Reich.⁵⁶

Postal, radio, and message intercepts by cryptanalysts at Bletchley Park, also proved very useful, with the message intercepts being the most important. These were primarily intercepts of short-wave radio communications between industrial firms on the Continent, which provided insights on the flow of component parts and finished goods, interruptions of deliveries by bombing and other means, the progress of repairs at damaged facilities, and the status of construction at new facilities. Of these intercepts, about 5 percent proved useful and 1 percent contained vital information. A particularly useful message, received like clockwork each week from 1940 until the summer of 1944 through intercepts of unencrypted Rumanian cables, provided exact figures on total Rumanian oil deliveries up the Danube to Germany. It would prove particularly useful as a BDA tool once Allied bombers began mining the river.⁵⁷

To obtain the latest photoreconnaissance cover of various industrial facilities, and to build what ultimately became a gargantuan set of files including every European economic concern of any note, MEW analysts developed a close liaison with ADI(Ph)

⁵⁶ Ibid., 3-5.

⁵⁷ Ibid., 5-6.

and the CIU. This interaction became particularly close in late 1940 when MEW began producing all of the economic intelligence for third-phase BDA reports and cooperated closely with photointerpreters in CIU's D (Industry) and K (Damage) Sections to produce 3rd-phase BDA reports. Aerial photographs provided crucial details on various industries, including the number of hydrogenation stalls at synthetic oil plants, reduction houses at aluminum plants, and assembly sheds at aircraft factories, all of which provided insights on the size, productive capacity, and vulnerabilities of these facilities.

Photoreconnaissance also worked exceptionally well in conjunction with agent reports, which provided intelligence such as number of employees at a plant, the number working in a particular section, and the total number of shifts working, all of which, when viewed in the light of photointelligence, allowed MEW analysts to determine the output and level of effort at industrial concerns throughout Germany and occupied Europe.⁵⁸

By working closely with their counterparts at the Ministry of Home Security, MEW analysts were also able to glean a great deal of information from production levels at British factories before and after German attacks, including the time required to repair the damage. In one of the war's richer ironies, therefore, the British turned bomb damage inflicted on their industries during the Blitz into actionable intelligence that allowed them to estimate with great accuracy the output of German factories, the likely damage caused by bombing, and therefore a rough idea of output at those factories. They combined this information with intelligence derived from military operations, including serial numbers, production dates, and locations of manufacture of captured equipment, allowing them to

⁵⁸ Ibid., 6-7.

estimate the size of production runs for various weapon systems such aircraft, tanks, and U-boats, and then to extrapolate larger production figures.⁵⁹

The real payoff came when MEW experts in each facet of the German war economy fused these intelligence sources to arrive at aggregate estimates of enemy productive capacity, and of the vulnerability of various industries to air attack. They also produced *de facto* BDA documents when they looked at Axis oil production, tank production, and locomotive production because these studies relied for their completion on damage assessments produced by CIU photointerpreters. These aggregate assessments proved extraordinarily accurate for all German industries, in most cases within 3-5 percent of ground truth, a fact made clear in the immediate postwar period as Allied survey teams gained direct access to German records for comparative purposes. The upshot of these efforts, by 1944, was the provision of very accurate intelligence to air commanders, giving them deep insights on the effects and effectiveness of air attacks against particular target sets.⁶⁰ The first indications of this harmonious relationship were already emerging when Bomber Command began the first oil offensive against Germany in late 1940.

6.4 Assessing a Key Nazi Vulnerability: BDA and the First Oil Campaign

The British had known long before the start of the war that Germany's greatest economic and military weakness was her shortage of oil. The Germans controlled perhaps three percent of the world's oil production at the start of the war and were never far from serious shortages during the first four years of the conflict.⁶¹ As an MEW

⁵⁹ Ibid., 7-8.

⁶⁰ Ibid., 9.

⁶¹ See SMS376, Army Air Forces Air Intelligence School, Photo Intelligence Division, *Photo Intelligence for Combat Aviation*, Part Two, Chapter IX, "Fuels," November 1943, 1-3, for an excellent summary of the Axis and Allied oil position. It noted that "In 1940, the United Nations produced over 96 per cent of the

historical report written near the end of the war emphasized, "No subject in the field of Germany's economic war effort has received greater attention than her oil industry."⁶² British intelligence agencies brought the full range of their country's technical, industrial, and service expertise to bear in their effort to determine Germany's oil position every three months from 1939 to 1945. This job was made easier by the fact that many of Germany's crude oil refineries and synthetic oil plants were owned by British and American companies before the war and had in many cases been designed and built by Anglo-American petroleum engineers. British and American technical experts had visited the majority of these facilities on many occasions before the war, and many of the plants were insured by British or American insurance companies. As a result, a wealth of knowledge was available to the Allied war effort, including plans, diagrams, photographs, key statistics, and the production processes employed at synthetic oil plants using the Bergius or Fischer-Tropsch production methods. British and American oil companies thus had a deep knowledge of most German synthetic oil plants and could make educated assessments about the very large Bergius plants started just before the war and completed during the war (Brüx, Pölitz, and Blechhammer North and South). Imperial Chemical Industries (ICI) had built several Bergius hydrogenation plants in the United Kingdom and thus had deep knowledge about their key processes, buildings, and vulnerabilities. Shared prewar research and development programs conducted with the

World's petroleum, the Axis nations and the lands they have conquered produced only 4 per cent. Greater Germany, Hungary and Japan combined produced 9.6 million barrels. The United States alone produced 1351.9 million barrels." The manual also noted the relative inefficiency of German synthetic oil plants: every 2,000 pounds of coal processed yielded 40 gallons of gasoline, 50 gallons of diesel fuel, 35 gallons of fuel oil, and 10,000 cubic feet of fuel gas.

⁶² AIR 14/1216, EAB (FO and MEW), "Intelligence on Enemy Oil Plants," 3 January 1945, 1. (Annex to report entitled "Inter-Departmental Machinery for the Appreciation of Oil Intelligence".)

Germans also gave British and American technical experts a very good understanding of the technical specifications of the large Bergius plants. British and American petroleum engineering firms also had an exact idea of German crude oil reserves, the locations of the oilfields, and a deep knowledge of the equipment used to drill for and pump oil, most of which they had sold to the Germans and installed for them. They had very precise figures on reserves, pumping capacity, and refining capacity. Equally important, petroleum experts also knew approximately how large the German oil reserve was at the start of the war, how much additional oil they acquired with each new annexation or conquest, and therefore what the entire German oil position looked like, taking into account German hydrogenation and crude plants as well as the reserves and production capacity in annexed, conquered, and allied states, including Rumania and the Ploesti oilfields. By late 1940, therefore, MEW analysts had gathered together these sources and had a very clear idea of German oil and fuel production and reserves.⁶³

Intelligence reports on oil during the war averaged 500-600 per week and were from the outset interagency products. Several agencies produced them, including MEW and the Lloyd Committee. This committee, formed at the request of the Chiefs of Staff in October 1939 under the chairmanship of Mr. Geoffrey Lloyd, Secretary of Mines, was instructed to keep the German oil position under continuous review. Members included the Directors of Intelligence from all three Services; representatives from the Foreign Office, MEW, the Prime Minister's Office, and the Petroleum Department; and civilian managers and technical experts from the oil industry. A body of technical experts under Sir Harold Hartley examined and collated all working materials. The Lloyd Committee

⁶³ Ibid., 1-2, 8.

reported to a Cabinet body known as the Hankey Committee on Preventing Oil from Reaching Germany, the members of which were Lord Hankey, the head of MEW, the Secretary for Petroleum, and the Parliamentary Under-Secretary of State for Foreign Affairs. This Committee was directed "to keep under review the action being taken to prevent oil supplies from reaching enemy powers and the organization required for this purpose," a thankless task given British inability to stop Rumanian and (prior to 22 June 1941) Russian supplies from reaching Germany. In March 1942 the Hankey and Lloyd Committees were disbanded. Sir Harold Hartley's technical experts and analysts were placed under the Joint Intelligence Sub-Committee (JIC), renamed the Technical Sub-Committee on Axis Oil, and given responsibility for tracking the enemy's oil position.⁶⁴

The Technical Sub-Committee on Axis Oil and its predecessors kept a constant focus on the German oil position and produced very accurate assessments, a fact confirmed during the war by Ultra intercepts and afterwards by captured documents and interrogations with oil plant managers and other officials, all of which confirmed that Allied assessments of production and reserves were almost always within 5 percentage points and often within one or two. They employed a huge array of intelligence sources, most of which coincided with the MEW sources outlined earlier. Among the most useful, early in the war, were cables sent between oil plants and refineries and Reich offices concerned with oil matters. These included valuable information on the location, type, and output of both old and new plants as the latter began production during the war.⁶⁵

⁶⁴ CAB 66/23, WP (42) 163, published within JIC (42) 147 of 20 April 1942.

⁶⁵ AIR 14/1216, EAB (FO and MEW), "Intelligence on Enemy Oil Plants," 3 January 1945, 2-3. (Annex to report entitled "Inter-Departmental Machinery for the Appreciation of Oil Intelligence".)

As it became available in increasing quantities, photoreconnaissance cover provided vital insights not just by corroborating other sources, but also in its own right by providing superb overhead imagery of every synthetic oil plant and crude refinery in Germany and the occupied lands. Aerial reconnaissance allowed intelligence analysts to determine the dimensions and exact layout of each plant, and its production capacity. With this information in hand, CIU photointerpreters cooperated closely with MEW oil analysts to determine with great precision the output at a given plant, and, once the major campaign against oil began in May 1944, reductions in output and the likely duration of repairs as a result of Allied bombing. Aerial photographs also allowed interpreters to determine the best and closest means for shipment of oil and fuel to depots, and to locate every fuel depot of any size throughout German-controlled Europe, which also paid huge dividends once the Allies had enough bombers to do serious damage to German oil production, shipment, and storage. Beginning in spring 1940, interpretation reports based on cover collected by photoreconnaissance Spitfires provided precise information on these depots, including the number of storage tanks, their capacity, and the amount of oil stored there. Given the great size of the major synthetic oil plants, they were even easier to locate, and also impossible to hide or move, two serious liabilities once they received sustained attention from Allied bombers in 1944-45. The same was true of drilling operations for crude oil and the construction of crude refineries, which gave analysts a clear idea of the scope and intensity of drilling, and of the amount of crude oil likely to be produced at each location.⁶⁶

⁶⁶ Ibid., 4. Producer-gas vehicles used special conversion kits that allowed them to run on wood or coal. The major drawbacks of these vehicles included the need to perform constant maintenance to keep their

Photoreconnaissance also worked very effectively in conjunction with less well-known intelligence sources. For instance, once Allied armies came into sustained contact with their German adversaries, mobile fuel-analysis laboratories on every fighting front analyzed samples of captured motor and aircraft fuel and lubricating oils to determine their quality, the frequency of maintenance on tanks, trucks, and aircraft, and the level of benzol, alcohol, and other substitutes mixed with motor and aviation fuels. They also published information on producer-gas vehicles. This in turn provided key information on the importance of benzol, which led to a concerted effort to photograph, bomb, and then assess the damage done to the many small benzol plants active in the Ruhr.⁶⁷

The thousands of assessments produced during the war on the German oil position were focused on four areas: production, consumption levels, reserves, and damage assessments. Damage assessments became accurate only after enough reconnaissance aircraft existed to take baseline photographs of all German oil installations and, once the 1944-45 oil offensive began, frequent BDA photographs. Technical experts at the CIU and MEW knew, from available cover, where the vital components of each plant were located, whether they had been hit in a given raid, and whether, given the presence or absence of steam emissions in various areas of each plant, it was out of commission, operating at reduced capacity, or operating at full capacity. With good PR cover, they could determine whether a given oil plant was working at 0%, 25%, 50%, 75%, or 100% of capacity. They were unwilling to attempt more precise estimates, but their accuracy in the aggregate was outstanding. The quantity and location of steam emissions also told

engines clean, and the increasing shortage of wood and coal, late in the war, to run them. They proved, in the final analysis, a false economy for Nazi Germany.

⁶⁷ AIR 40/1816, Air Ministry, *Photographic Intelligence during the European War*, 30 June 1945, 20.

PIs and technical experts within plus or minus seven days, and usually within a day or two, when a plant would begin production once again after a period of repairs. In no case did a plant begin production before an assessed date.⁶⁸

From the earliest days of the war, British oil experts tracked German oil production, the capture of additional stocks, and fuel used in major operations. For instance, MEW analysts assessed that heavy fuel consumption on the Eastern Front in 1942 and 1943, when combined with a large number of new economy measures in the Reich picked up by Ultra and other sources, signaled the depletion of German oil reserves. Their assessment proved correct.⁶⁹

One of the little-remarked but crucial ironies of the Allied oil offensives, the first (1940-41) very small and utterly unsuccessful, and the second (1944-45) of decisive importance in influencing the rapidity with which Allied armies defeated their German opponents, is that the earlier offensive made the Germans complacent, leading them to eschew dispersal and hardening efforts until the great storm was already upon them with the start of the second oil offensive in May 1944. This problem was made worse by the fact that Germany had no incentive to erect new refineries since, until May 1944, refinery capacity was greatly in excess of available crude supplies. Germany's tardy dispersal and hardening efforts were augmented by the maximum possible use of benzol, alcohol, producer gas, and bottled butane as energy for motorized and mechanized vehicles. Benzol is a by-product of the carbonizing of coal by coke-ovens and gas works. However, since Allied intelligence personnel had already located all 115 benzol plants in

⁶⁸ AIR 14/1216, EAB (FO and MEW), "Intelligence on Enemy Oil Plants," 3 January 1945, 5-6. (Annex to report entitled "Inter-Departmental Machinery for the Appreciation of Oil Intelligence".)

⁶⁹ Ibid., 7-8.

Germany and the other 20 in Austria, Czechoslovakia, and Poland, they knew the approximate maximum output of benzol and had already recommended the 20 largest plants for attack as of January 1945. Sources of production for alcohol and blending agents such as tetra-ethyl lead and iso-octane, used to make high-octane aviation fuel were also well known to British intelligence specialists by 1942. In fact, almost all of these blending agents were produced at the large Bergius plants, making them the most important targets, since their destruction would result in an immediate and severe aviation fuel shortage, a nightmare scenario that became an operational reality for the Luftwaffe in summer 1944.⁷⁰

This uniquely intensive intelligence effort, combined with the frequent use of industry expertise, and confirmed by photoreconnaissance cover, ULTRA intercepts, and other sources, led to a good understanding of the German oil industry by 1941, and a particularly deep one by 1943. It also provided the underpinnings for a sound targeting effort in 1940-41 and a superb one in 1944. The key difference was a lack of capable bombers, bombsights, navigational techniques, bombing tactics, and effective munitions in 1940-41, and their presence in 1944-45. In the latter case, mature and outstanding Allied aerial reconnaissance, signals intercept, and human intelligence capabilities facilitated remarkably accurate assessments of the effects and effectiveness of bombing on German oil and fuel production.⁷¹

Discussions on the possibility of bomber attacks on German oil installations began in September 1939, when Bomber Command officers discussed the operational feasibility

⁷⁰ Ibid., 9-10.

⁷¹ Ibid., 11.

of attacking oil storage depots, synthetic oil plants, and crude oil refineries in range of their medium bombers. Their discussions were based on Bomber Command Operation Order No. 11, which dealt with an air offensive against German oil installations and provided details on types of oil targets, their key vulnerabilities, and optimum methods of attack. Mr. Gordon Bell, a petroleum expert employed by the Anglo-American Oil Company, provided detailed insights on Hamburg's oil refineries along with superb photographs of representative plants and storage depots in the UK, all for the purpose of assisting with the implementation of ordnance tests to determine if incendiary bombs could light heavy oil spilling from ruptured oil tanks, and with the execution of a bombing campaign once British airmen received authority to begin one.⁷²

By the following month, the Air Ministry had joined in these discussions, providing insights on the key components for producing oil at Bergius plants, including their hydrogenation stalls, water-gas units, carbon-monoxide (CO) conversion plant, and sulphur purification works, all of which presented a target about 40 acres in size. Vital components at Fischer Tropsch plants included their water-gas units, CO conversion plant, sulphur purification works, contact oven house, and condensers. The distillation and cracking plants at both types of facilities were also vital, but for production of fuel rather than of oil from coal. Equally vulnerable were the overhead pipes present in great numbers at each plant for the piping of steam pressure to the various plant components.

⁷² AIR 14/97, "Appendix "C" to Bomber Command Operation Order No. 11," 24 August 1939; AIR 14/97, "Discussion at Bomber Command on 18.9.39 on attacks on oil storage depots and plant"; AIR 14/97, Memo, Gordon Bell to Group Captain Wells, Ordnance Board Office, 28 September 1939. A key attendee at these early meetings was Air Commodore Norman Bottomley, then Bomber Command's Senior Air Staff Officer, who in 1944, with General Carl Spaatz, became a leading advocate of the attack on German oil. Once he and Spaatz became executive agents for Allied strategic bombing in September 1944, a continued focus on oil attacks was assured.

Without this high-pressure steam, the plants could not produce oil. Airmen and ordnance experts agreed that 250-lb. bombs combined with incendiaries would cause the greatest damage to oil plants, particularly if the bomber crews caught them by surprise while up and running. Although the RAF Ordnance Department conducted bombing tests using 4,000 gallons of fuel oil, only the 40-lb. magnesium-thermite bomb worked. The 4-lb. incendiary failed because it was extinguished by the fuel oil before it could light it afire.⁷³

Mr. Bell continued his correspondence with Bottomley after the conclusion of these meetings, providing suggestions on the most effective tactics and bombs for the attack on oil targets, the capacities of refineries in Belgium and Holland, and detailed information on Belgian and Dutch oil infrastructure. Bottomley and his counterparts at the Air Ministry also learned a good bit from an article in a French professional journal that confirmed the Germans had already employed the same weapons mix against Polish oil refineries and storage depots that the British hoped to employ against the Germans' oil installations. The document's key finding was that the Germans had used a mix of 550-lb. high-explosive bombs and small incendiary munitions, the first of which caused oil tanks to collapse and the second of which then ignited the spilled oil. By November 1939, Bottomley was referring to "our oil plan" in correspondence in an internal Bomber Command Minute, and once the threat of invasion of the British Isles subsided in that month, a British bombing campaign against German oil assets was not long in coming.⁷⁴

⁷³ AIR 14/97, A.I.1(B), Review of German oil and fuel production, 12 October 1939; AIR 14/97, "Oil Ignition Trials: Shoeburyness 17th Oct. 1939"; AIR 14/97, "Oil Ignition Trials: Shoeburyness 14th November, 1939."

⁷⁴ AIR 14/97, report, Bell to Bottomley, 11 December 1939; AIR 14/97, Translated Article from *La Revue Pétrolifère*, "How Germany Attacked Petroleum Plants in Poland," 13 January 1940; AIR 14/97, Minute, HQ Bomber Command, 6 November 1939. Bottomley referred directly to "our oil plan" here.

The focus of the "First Oil Offensive," as the small and ineffectual British series of raids between May and September 1940 might best be called, was ostensibly on oil, but the incredible dispersion of effort on an entire range of target sets, including aircraft, aluminum, chemicals and explosives, electric power, iron and steel, and shipbuilding, ensured that Bomber Command's assets, already limited to begin with, would produce truly meager results. In fact, the profound discouragement brought on by results that were clearly very limited, combined with the need to attack invasion barges in the Channel ports, led to the gradual and quiet abandonment of this first effort against oil. However, in the process the British learned much about the value of both the PDU and the PIU for providing excellent BDA photographs and accurate damage assessments.

The effort against oil, and against the many other targets attacked with miniscule numbers of bombers during the same period, represented an effort to engage in what amounted to night precision bombing. Daylight raids during May and June 1940 in support of British and French ground forces had produced appallingly high casualties, and after that point there was a rapid shift to night bombing. The problems with this approach, from a BDA perspective, were significant. To begin with, strike photographs collected by bombers with cameras aboard produced nothing but a series of bright dots, blobs, and lines that represented flares, bomb hits, fires, tracers, and the flight paths of damaged bombers. Learning to decipher the information contained in such photographs took time, and it was not until late 1941 that such a capability developed in the newly-formed Night Sections at CIU and HQ Bomber Command. In addition, pilots' reports tended to be wildly optimistic, claiming significant damage. Examples of this included the 22-23 July 1940 night raid on the synthetic oil plant at Gelsenkirchen, in which 18 of

the 19 Hampden medium bomber crews involved in the raid claimed direct hits on the facility. Aircrew debriefings contained a note that "bombs were seen to burst on the target, fires started and heavy explosions followed." A similar story unfolded after the 27-28 July raid by Wellington bombers on oil refineries at Hamburg, after which pilots reported that "hits were observed on the oil refinery, followed by two fires and two explosions. Bombs straddled the second refinery and three fires were seen."⁷⁵

Unfortunately, the PDU and PIU were not yet mature enough to provide regular post-strike reconnaissance and damage assessments for these raids. They were still trying to recover equipment losses sustained during the Battle of France, and the handful of PDU Spitfires then available stayed fully employed in the reconnaissance of German and Channel ports as the possibility of invasion became a serious concern. Consequently, BDA sources available for these early raids on oil installations included the same kinds used in World War I: pilots' debriefings, agent reports, and inputs from neutral parties. An overly optimistic view of attacks on oil and other targets thus prevailed, with MEW BDA reports often listing virtually every target attacked as having been hit. In one such report, of the 22 oil targets attacked by at least one bomber during the period 29 July to 11 August, including 14 crude oil refineries and 8 oil plants in western Germany, three were assessed as having been "heavily damaged and probably out of action," 13 as "heavily hit but probably still operating," and six as "hit but probably still operating."⁷⁶ The fact that all of these targets were attacked at night, often without moonlight for

⁷⁵ Webster and Frankland, *Strategic Air Offensive*, Vol. I, 218.

⁷⁶ AIR 14/784, MEW, Mr. Lawrence, "Industrial Targets Report No. 3 (Period July 29th-August 11th, 1940)" 20 August 1940, 1-3.

illumination, and often by strike packages of only one, two, or three bombers, leaves one wondering how aircrews and intelligence agencies could have believed their own reports.

Portal did not believe them and set out to secure more reliable means of determining the damage done by his bomber crews. Writing to the Air Ministry about "the lack of information on the results of our bomber attacks, and the very small number of photographs which it has been found possible to take of objectives which have been bombed," he asked for more photos and an oil expert to help him interpret them.⁷⁷ The good news is that Portal received both, the former from an increasingly capable PDU with larger numbers of Spitfires, and the latter in the form of Mr. D. A. C. Dewdney, a civilian oil expert. The bad news was that both soon exposed the very poor bombing accuracy against oil targets and every other kind of target, with the exception of attacks on invasion barges, which generally produced good results. In the days following raids on oil targets in December 1940, when PDU Spitfires began taking post-strike photos on a regular basis and PIU interpreters began producing damage assessments, it quickly became clear that the bombers almost always dropped their bombs wide of the target.

The results of damage assessments for raids carried out against the two oil plants at Gelsenkirchen during the first three weeks of December 1940 proved discouraging. A total of 196 medium-bomber sorties delivered 260 tons of bombs during these raids, with the vast majority of aircrews claiming accurate bombing and significant damage. In fact, only very minor damage was done and very few bomb craters were visible anywhere on

⁷⁷ AIR 20/2780, Memo, Portal to Air Ministry, 29 July 1940.

BDA photographs. The majority of bombs had fallen outside the area of photographic coverage, meaning that bomber crews missed their targets by several miles.⁷⁸

Mr. Dewdney added to this gloomy picture with his assertion that intelligence analysts at MEW, who produced most of the BDA reports for attacks on oil installations, had badly underestimated the weight of attack required to destroy them. He also pushed for the use of the 500-lb. bomb, rather than the 250-lb. version more commonly used, stating that they had done the most damage in the rare instances when British bombs had actually fallen on oil plants. Dewdney pointed out that a recent German bombing raid on the Anglo-American Company fuel depot at Purfleet using 500-lb. bombs had done serious structural and fire damage to a number of storage tanks. "The experience at Purfleet," Dewdney said, "seems to suggest the value of heavy demolition bombs as compared with light splintering bombs in attacking storage, and if the tendency to brick up tanks in enemy territory evinced by recent photographs of [Target] A.2 [Deutsche Vacuum crude refinery in Bremen] is carried further, the use of the heavy bomb is further supported."⁷⁹ Tests later confirmed Dewdney's view that the 500-lb. bomb was not only more destructive than the 250-lb. version, but was also much more effective *pound-for-pound*. Dewdney also called for the use of bombs with delayed-action fuses to keep repair crews at bay and inflict additional damage by setting leaking oil and fuel afire.

⁷⁸ Photographic Interpretation Report, PIU, 28 December 1940, cited in Webster and Frankland, *Strategic Air Offensive*, Vol. I, 228. See also AIR 14/784, Memo, Dewdney to Air Chief Marshal Peirse [who had replaced Portal as head of Bomber Command], 1 January 1941, in which Dewdney, having studied the increasingly frequent and effective PDU photos and PIU damage assessments, informed Peirse that bombing accuracy against the Gelsenkirchen and Scholven oil plants was poor, with most aircraft missing the targets by several miles.

⁷⁹ AIR 14/784, Memo, Dewdney to Portal, 4 September 1940, 1, and attached report, "Attack on German Oil Targets: Preliminary Survey," 5; AIR 14/784, Memo, Dewdney to Portal, "Attack on Bulk Storage," 26 September 1940, 1-2.

Most important for the development of British BDA capabilities, however, was his decision to obtain data from the Ministry of Home Security on the effects of German air attacks on British oil plants and refineries, as he had done in his MEA report for the German attack on the Purfleet oil storage depot. Dewdney believed that such data would yield a huge amount of valuable information for determining how best to bomb similar targets in Germany. His assertions proved correct, leading ultimately to the creation of Research and Experiments Department 8 (RE8) in 1942, which became a key intelligence producer in conjunction with the CIU and MEW. Once up and running, RE8 employed records of German damage to British industries as a comparative baseline for providing very detailed BDA and MEA reports for British and American bombing raids as well as studies tracking the status of German reconstruction and repair efforts. This development, which proved to be of fundamental importance to the creation of a mature BDA intellectual infrastructure, is attributable almost entirely to Dewdney's efforts.⁸⁰

Equally important for later targeting, BDA, and MEA efforts was Dewdney's decision to conduct a thorough analysis of the likely damage required to destroy or render inoperative for long periods various German oil plants and refineries, estimating that the weight of attack required for 75 percent destruction of an average crude refinery was 70 tons of bombs, and 120 tons for a synthetic oil plant. Using existing BDA reports with their meager complement of aerial photographs, Dewdney estimated the loss of output at German synthetic oil plants as a result of British air attacks to date at 100,000 tons, concluding that the plants thus far attacked were between 58% and 80% *undamaged*. He

⁸⁰ AIR 14/784, Memo, Dewdney to Portal, 4 September 1940, 2, and attached report, "Attack on German Oil Targets: Preliminary Survey," 2.

also assumed a 300-yard average bomb aiming error and a repair rate at German oil facilities of 6.7 percent per month. Although his figures were unduly optimistic, based as they were on a limited number of often-inaccurate BDA reports, Dewdney's methodology was sound, even if the accurate and detailed BDA reports he needed to make accurate quantitative and qualitative judgments did not yet exist. They would be on hand in large numbers by 1943, allowing BDA experts to employ Dewdney's methodology to great effect in determining the damage done to oil installations during the 1944-45 oil offensive. Dewdney's tentative attempts at detailed BDA thus provided the first clear indication that BDA would become more accurate and sophisticated over time with the employment of quantitative analysis based on detailed and accurate damage assessments.⁸¹ Also crucial to later bombing campaigns was Dewdney's conclusion that

for a given number of bombs, loss of output is caused most effectively by putting on the heaviest possible attack in the shortest time, rather than by nibbling at short intervals at the target...it is clear that one heavy attack causes a considerably greater loss of output due to loss of capacity than a number of smaller ones with the same total of bombs over the same period of time.⁸²

This assertion also lent credence to Dewdney's argument in favor of using larger bombs. In fact, he later posited that between 5,000 and 6,800 500-lb. bombs would be required to shut down all of Germany's synthetic oil plants. An even more fundamental observation—and a correct one—was that taking out any one of the five key elements of a synthetic oil plant (hydrogen manufacture, hydrogen purification, hydrogen

⁸¹ AIR 14/784, Memo, Dewdney to Portal, 4 September 1940, 1-2, and attached BDA report, "Attack on German Oil Targets: Preliminary Survey," 1-5; AIR 14/784, Memo, Dewdney to Air Chief Marshal Sir Richard Peirse [the new head of Bomber Command with Portal's promotion to Chief of Air Staff], 1-2, and attached BDA Report, "Attack on German Synthetic Plants: Quantitative Damage," 22 October 1940, 1-4 and Tables I and II.

⁸² AIR 14/784, Memo, Dewdney to Air Chief Marshal Sir Richard Peirse [the new head of Bomber Command with Portal's promotion to Chief of Air Staff], 1, and attached BDA Report, "Attack on German Synthetic Plants: Quantitative Damage," 22 October 1940, 3.

compression, oil pumping and process control, and high pressure reaction) would shut it down for weeks or months. This result would be feasible, he continued, only if British bombers concentrated all their efforts on one plant until it was destroyed, and then moving on to the next one. Dewdney closed with three observations. First, he said, synthetic oil plants were the most vulnerable of all industrial targets and the most important to the German war effort. Second, the dispersion of German bombing efforts in attacks on British targets showed the ineffectiveness of such an approach, meaning the British dispersion of bombing effort (which, as we shall see shortly, reached absurd levels during the fall of 1940) should be stopped immediately. Third, concerted attacks on these oil plants, even at the expense of attacks on other target sets, made the most sense in terms of bombing effectiveness. If his program were followed, Dewdney said, it would deprive the Germans of one million tons of oil in the next six months.⁸³

Dewdney's methods were, in short, positively Tivertonian and represented the first effort since Tiverton's to apply operational research techniques to the problems associated with bombing oil targets. Although his figures proved far too optimistic, they represented a first step towards assessing systematically the vulnerability of German oil facilities to bombing attacks and the effects of Allied bombing raids against them.

These improvements in the bombing and BDA process were, however, still largely in the future, and in the meantime the absence of good photoreconnaissance cover was the central factor in Dewdney's failures of analysis. He labored under much less propitious conditions for conducting BDA than he and his successors did towards the end of the war. He also fell into the trap of assuming that British bombers were navigating

⁸³ AIR 14/784, Dewdney to Peirse, "Attack on German Oil Supplies," 17 December 1940, 1-3.

effectively to their targets and dropping bombs with an average error of 300 yards—a fantasy figure that proved dramatically better than even the best British and American aircrews were able to achieve, on average, during the last year of the war. Dewdney's estimates for the bomb tonnage needed to destroy German synthetic oil plants also proved to be only a tiny fraction of the tonnages ultimately required. Still, he had a number of excellent insights, and he would bring them up again, much later in the war, when the number of Allied bombers and a mature BDA infrastructure came together to facilitate the devastating attacks on oil plants during the 1944-45 oil offensive.

In the meantime, Bomber Command's senior officers seemed determined to make the small numbers of aircraft at their disposal as *ineffective* as possible by spreading them across multiple target sets and sending them after their targets in tiny numbers—often one or two bombers at a time—even though their operational directive still made oil the number one priority. During the 17-day period between 23 August and 8 September 1940, for instance, British bombers carried out 31 attacks against 20 different oil targets, including seven synthetic oil plants, four crude oil refineries, and nine oil storage depots. However, they also made 57 attacks on 35 other targets including eight aircraft factories, one aluminum plant, five chemical and explosives plants, five natural gas and coke-oven targets, seven electric plants and transformer stations, two iron and steel plants, three shipbuilding targets, and four engineering firms. Of these attacks, 35 were made by *one* bomber, 10 by *two* bombers, and another nine by *three* bombers. Most of the rest were made by between four and six aircraft. Only seven raids involved 10 or more bombers, the largest with 20 bombers. When we recall that each medium bomber carried only 2,500 lbs. of bombs (mostly of the 250-lb. variety), made their attacks at night under

conditions of poor visibility, and had rudimentary navigation systems and bombsights, it becomes clear why the first effective BDA photographs taken in summer and fall 1940 revealed so little damage and so many bomb craters miles from their targets. What makes this even odder is the fact that the Air Ministry had a standing Targets Committee charged with selecting appropriate targets, a task clearly beyond their means. Small wonder, then, that Dewdney called for larger-scale attacks, concentrated on a few high-value oil targets, and using larger bombs. His recommendations for precision attacks on these targets would await the arrival of American senior airmen and bomber crews, who, serendipitously, set about carrying out Dewdney's—and Tiverton's—program under the guise of their own high-altitude, precision, daylight bombardment doctrine.⁸⁴

The British bombing effort became positively bizarre for a few weeks in September 1940 when several missions attempted to start large conflagrations in the woods of the Black Forest and Thuringia, the idea being to reduce the amount of wood available for construction and other military purposes. And the operational bad habits continued, with an incredible dispersion and dissipation of Bomber Command's limited assets. Of the 67 individual attacks recorded from 23 September to 6 October 1940, 30 involved *one* bomber, seven involved *two* bombers, and eight involved *three* bombers. Another 13 missions had between four and seven bombers each, while the other nine missions involved between eight and 10 bombers. Not a single mission involved more than 10 aircraft. And in spite of the fact that Channel ports and oil targets had overriding priority in Air Ministry and Bomber Command operational directives, during this two-week

⁸⁴ AIR 14/784, MEW, "Industrial Targets Report No. 5 of September 12th 1940,"; AIR 14/784, Memo, Air Ministry D.O.I. to C-in-C Bomber Command, 20 September 1940, with draft MEW memo for Target Committee use. Ironically, this memo requested Dewdney's inputs for the upcoming Target Committee meeting at the Air Ministry on 23 September 1940. Clearly, nobody listened to him.

period they received only 16 percent and 15 percent, respectively, of the entire bombing effort. Another 23 percent went to aircraft factories and 37 percent to communications targets (now called transportation targets, these included railroad marshalling yards and inland waterways). The rest went to miscellaneous targets such as electric power and chemical (explosives) plants.⁸⁵ As unsound as this practice was operationally, it was even worse from a BDA standpoint.

Although by late 1940 the official establishment for night-capable strike cameras to put aboard bombers was four per squadron (and hence 168 total for the 42 squadrons then in service), there were in fact only 22 such cameras available for all of Bomber Command as late as January 1941.⁸⁶ Given the large number of raids and the very small number of cameras, bomber crews obviously collected very little strike photography. Even when night strike photos were available, the techniques for analyzing them were still in their infancy at the PIU and at the HQ Bomber Command Intelligence Directorate. Flying night missions also made visual observation very difficult. Consequently, the entire effort devolved largely to guesswork, unless reconnaissance Spitfires, still very few in number, were able to obtain post-strike cover. Here again, the dissipation of the bombing effort proved problematic because the still-small number of Spitfires could not possibly cover all the targets struck, and even if they could, the F6 (6" focal length) lenses on their F24 cameras could provide only small scale prints that revealed little even under the gaze of trained PIs with the Wild machine or stereoscopes. The fact that the

⁸⁵ AIR 14/784, MEW, "Industrial Targets Report No. 7 (Period September 23rd - October 6th, 1940)", 10 October 1940. For a listing of attacks on different target types by percentage of total effort, see 4. For the dispersion of effort in these attacks, see Middlebrook and Everitt, *Bomber Command War Diaries*, 85-89.

⁸⁶ The camera shortage is described in Memo, Peirse to Beaverbrook, 13 January 1941, cited in Webster and Frankland, *Strategic Air Offensive*, Vol. I, 222.

bombers in question were two-engine Hampdens and Whitleys, neither of which could carry more than 2,500 pounds of bombs, made the problem even more serious because even if they did hit the target, the small number of bomb strikes was not readily apparent on the small-scale photos.⁸⁷

Still, it became obvious, gradually at first but with increasing clarity in 1941, that the majority of bombers were not putting their bombs anywhere near the target—a fact that even small-scale photographs could confirm. In fact, on New Year's Day, Dewdney sent Air Chief Marshal Peirse what could only have been a discouraging note about the effects of bombing raids on German oil plants and refineries. "Both P.I.U. and ourselves," Dewdney said, "therefore agree that only minor damage is visible at Scholven and Gelsenkirchen...These disappointing results are unexpected since Scholven and Gelsenkirchen are the two synthetic oil plants most heavily attacked to date."⁸⁸ Dewdney had previously assessed Scholven at 40% damaged and Gelsenkirchen 10%. Both these figures were too optimistic, the one for Scholven wildly so.

He concluded with the somber assertion that "From the photographs it is evident that a large proportion of the bombs reported as having been dropped over the targets were in fact dropped elsewhere." Dewdney did not quantify what "elsewhere" meant, but as the Butt Report would show just over eight months later, it meant anywhere from one to eight miles from the target, with 80 percent of all Bomber Command sorties dropping their bombs over five miles from their intended targets. The point here is not that the

⁸⁷ AIR 14/597, Bomber Command, "Note on the Proposed Reorganisation of the P.R.U.'s and C.I.U.," October 1940, 1-2, said there were four Spitfire flights at this point, each with four aircraft. These 16 Spitfires had to watch the Channel and German ports, photograph high-value economic and military installations, and collect BDA photos. Needless to say, watching the ports for signs of an invasion had the highest priority until the end of October 1940.

⁸⁸ AIR 14/784, Memo, Dewdney to Peirse, 1 January 1941.

raids did nothing—in several cases they did moderate damage that took the Germans days or even weeks to repair—but that they were made by small numbers of aircraft, not repeated with any regularity, and in most cases missed the target, dropping their bombs either on decoys or in the open countryside.⁸⁹

Photointerpreters also missed some basic things at this early stage of the war. For instance, the Germans routinely shut down their oil and other industrial plants immediately after air raids to assess the state of the plant and to clean up any flammable liquids that might have been spilled as a result of the attack. This was standard practice even if it was thought that no damage occurred. British photointerpreters, who took plant shutdowns as a sign of serious damage, did not discover their error until 1942. It was part of the gradual and iterative learning process that all photointerpreters and other BDA experts went through during the course of the war.⁹⁰

On the other hand, Dewdney and photointerpreters at the PIU did get some important things right very early in the game, such as their recognition of the “exceptional efficiency” of the German salvage and reconstruction crews, which, it continued, “are extremely well organized and plentifully supplied with equipment and material. This will

⁸⁹ The issue of decoys was important, as Edward Westermann made clear in “Hitting the Mark, but Missing the Target: Luftwaffe Deception Operations, 1939-1945,” *War in History*, April 2003, 10 (2), 206-221. Westermann noted that by November 1940, Bomber Command missions sometimes dropped as much as 70 percent of their bomb loads on decoy sites. This tells us the decoy sites worked well early in the war and that British bombing was not as inaccurate as the Butt Report stated. British aircrews *were* sometimes hitting what they aimed at even though it was not the intended target. As the British became aware of the problem, dedicated sections at the CIU and Bomber Command were formed to deal with it. The effectiveness of German decoys thus decreased after 1941 but retained an ability to draw bomber crews away from their targets until late 1944. For insights on the Butt Report, published 18 August 1941, see AIR 8/440, Minute, Cherwell to Churchill, Summary of Butt Report, 2 September 1941.

⁹⁰ See AIR 14/784, MEW, “Industrial Targets Report No. 7 (Period September 23rd -October 6th, 1940”), 10 October 1940, 2-3. This BDA report noted that oil plants might shut down for two reasons: threat of imminent attack, and actual damage caused by an attack. It missed the fact that the Germans routinely shut down their plants *after every attack* to determine whether, or how much, damage had been done.

clearly have to be taken into account in estimating the probable duration of partial damage to industrial plants.”⁹¹ Ironically, if the British knew just how efficient German repair crews were, how poor their bombing was, how far off the mark their early BDA reports were, and how badly their dispersion of effort undermined the effectiveness of their bombing, they might have given up the enterprise altogether. Fortunately for the Allied war effort, they did not. And through this first phase of the bombing effort, BDA skills improved steadily, as did the ability to make reasoned judgments about the accuracy, effects, and effectiveness of Bomber Command operations.⁹²

What the British needed desperately in their BDA arsenal, particularly after they had been ejected from the Continent, was an organization, comprising adequate numbers of high-altitude, long-range reconnaissance aircraft, and improved aerial cameras, and an organization devoted entirely to interpreting the aerial photographs taken with those cameras. Only this would allow them to piece together an accurate picture of the German war economy and the damage British bombing was doing to it. Both were already well on the way to maturity at the PDU and PIU by the end of the year, and the much more accurate and voluminous BDA photographs and reports they provided during 1941, once there were three Spitfire photoreconnaissance squadrons in action, would provide a severe jolt to the British senior leaders who orchestrated the bombing effort, leading them to turn away from any pretense of “precision” bombing and decisively towards the night, city bombing campaign for which Bomber Command became best known.

⁹¹ AIR 14/784, Memo, Air Ministry Director of Intelligence to C-in-C Bomber Command, 20 September 1940, 8.

⁹² AIR 14/784, Memo, Dewdney to Peirse, “Vulnerability of Oil Targets,” 17 December 1940.

CHAPTER 7

THE SHIFT TO NIGHT AREA BOMBING: BDA, DOCTRINAL EVOLUTION, AND OPERATIONAL CHANGE, 1941-42

7.1 British Bombing in Crisis: BDA and an Awareness of Inaccuracy

The end of the invasion threat in October 1940, combined with worsening weather, limited Bomber Command's activity during the winter. Air Ministry directives continued to make oil the top priority, but dispersion of the bombing effort continued. In January 1941, as additional reconnaissance Spitfires provided more post-strike photos, and as photointerpreters at the PIU improved their damage-assessment skills, the story became even bleaker than it had been the previous fall: The vast majority of bomber crews were dropping their bombs thousands of feet or even several miles from their targets. The early months of 1941 also produced an operational crisis as aircrews struggled to learn better navigation techniques and waited for the arrival of the promised "heavies": four-engine bombers, the first of which, the Short Stirling III, began arriving by summer 1941. Tactical problems also abounded. Although RAF doctrine still made daylight bombing the standard, day raids had all but ceased by 1941. As aircrews flew more night raids, at first hoping vainly that they could carry through precision attacks and then turning to area raids on cities, BDA capabilities evolved to assess the effects of these new tactics.¹

¹ For a succinct summary of the tactical and operational problems facing the British bomber force in early 1941, see Middlebrook and Everitt, *Bomber Command War Diaries*, 92-94.

7.2 The Oil-versus-Night Bombing Debate, The Butt Report, and BDA

By January 1941 the Combined Chiefs of Staff (COS) were becoming alarmed at what they saw as a wasteful dissipation of effort in Bomber Command and a failure to focus on the target set specified in COS and Air Ministry bombing directives: oil. Based on recommendations in the 5th Report of the Lloyd Committee, which was charged with assessing the German oil position, the COS argued in favor of an air offensive against oil for a six-month period, or, alternatively, morale attacks on cities. Emphasizing a need for the “greatest possible economy of force” given the scarcity of bombers, they supported a concerted attack on oil, dismissing aircraft production, anti-invasion targets, transportation, and naval objectives as secondary in importance and not worth the effort required to attack them. Based on Lloyd Committee and Joint Intelligence Sub-Committee (JIC) analyses pointing to oil as the most vulnerable target set, the COS believed attacks on the seventeen largest oil plants would pay the greatest dividends and might reduce German oil production by 83 percent after four months. The only targets that might occasionally take higher priority were the Channel ports, if an invasion attempt appeared likely, and German naval forces, particularly surface raiders and U-boats, if they could be caught outside their ports.²

The Chiefs called for an immediate attack on oil to take advantage of the long winter nights but also hedged their bets by proposing a secondary target: morale. They said attacks on German oil plants would have some effect on morale simply because many of them were in or near urban areas, which meant stray bombs would strike residential

² AIR 8/1016, COS (41) 19, “Air Bombardment Policy,” 7 January 1941, 4-5. The seventeen oil plants, in order of importance, were Leuna, Pölit, Gelsenkirchen (Nordstern), Zeitz, Sholven Buer, Ruhland, Böhlen, Magdeburg, Lützkendorf, Sterkrade Holten, Homberg, Kamen, Wanne Eickel, Bottrop, Dortmund, Castrop Rauxel, and Brück.

areas. Further, they stipulated that all bomber crews sent after oil plants were to have secondary targets, in urban areas, in case weather forced them to divert. These targets included industrial areas and marshalling yards in cities.³ Given the still-rudimentary state of navigation instruments and bombsights, these alternates were essentially area targets to be bombed for both material and morale effects. The old urge to go after morale began to reemerge, but it did so *in conjunction with* a focus on achieving the greatest material effects, not as an alternative to them. Still, the door was again open, and Arthur Harris, once in charge of Bomber Command, would make this combination of material and morale effects the centerpiece of his city-bombing campaigns.

The Chiefs of Staff also mentioned another means of getting at German oil supplies: an attack on the nine crude oil refineries around the Rumanian town of Ploesti, which by this time were supplying over a third of Germany's oil. Interestingly, they recognized the importance of Rumanian oil supplies for Germany's war effort but concluded that

Although the stoppage of Roumanian supplies would be the biggest single blow to the German oil position *the destruction of his synthetic oil plants in Germany alone would bring about a crisis...* The interruption of Roumanian supplies, in addition to the destruction of the synthetic oil plants might render Germany impotent before the end of 1941.⁴

Aside from the fact that the British lacked the bomber force to bring off this double play, they also needed permission to use Greek air bases for the bombing of Ploesti, not a sure thing given Greek leaders' concerns that such a move would invite a German attack.

Despite these issues, the War Committee, comprised of the most senior civilian and military leaders and chaired by Prime Minister Winston Churchill, approved the COS

³ Ibid., 5. Trenchard's influence was at work in the COS decision to make morale a secondary focus.

⁴ Ibid., 4. Emphasis in original.

proposals.⁵ This was no surprise given Churchill's interest in an attack on oil and his statement to the Secretary of State for Air, Sir Archibald Sinclair, in November 1940, that he wanted a plan drawn up for bombing Ploesti from Greek air bases. Sinclair passed this order along to his Chief of Air Staff, Air Chief Marshal Sir Cyril Newall, who in turn directed his air chief in the Middle East to begin making preparations for bombing operations.⁶ The Director of Plans responded with a proposal to attack with five squadrons (three of Wellingtons and two of Blenheims—a total of 80 aircraft), dropping 258 tons of bombs per month, which he said would achieve 25-30 percent destruction of the Ploesti refineries within four months.⁷

Pronouncements about a two-pronged oil offensive were one thing; operational realities another. Winter weather made attacks infrequent, and even when favorable conditions existed, British bombers went after virtually everything *except* oil. For the first four weeks after the War Committee confirmed oil as the top priority, British bombers went after *one* such target: an oil-storage facility in Holland. The eight Blenheims sent on the raid turned back without bombing. Then, beginning the night of 10-11 February, three interesting things happened. First, British bombers began attacking oil plants more frequently. Second, they did so in strike packages of from 40 to 70 aircraft per target—much larger raids than previously. Third, they also began making larger-scale attacks on German cities, either as alternate targets, or in an increasing

⁵ AIR 8/1016, Minutes, War Committee meeting, 13 January 1941,

⁶ See AIR 8/434, Minute, CAS to Director of Plans, 28 November 1940, which refers directly to Churchill's wishes for air attacks on Ploesti, and AIR 8/434, Cable, Air Ministry to A.O.C.-in-C. Middle East, 28 November 1940.

⁷ AIR 8/434, 1452-1456, Air Ministry, Directorate of Plans, "Appreciation on the Scale of Effort and Possible Results of an Offensive against the Roumanian Oil Resources with the Air Forces at Present Available in Middle East, Operating from Aerodromes in Greece," 28 January 1941, 2-5.

number of cases as primary targets, as in the case of a 222-bomber raid on Hannover the night of 10-11 February, the largest single attack to date.⁸ The first development was driven by two factors: the directive to Air Chief Marshal Peirse, head of Bomber Command, to get after oil targets, and a period of good visibility brought on by clear weather and a waxing moon. The second—larger-scale raids—was significant because it indicated that Peirse had begun to listen to Dewdney, PIU photointerpreters, and MEW oil analysts, all of whom agreed that, if nothing else, post-strike photographs and damage assessments made clear the importance of massing large numbers of bombers over each target. The larger-scale attacks on cities were born of expediency—the need to hit alternate targets when oil targets were obscured—and the creeping reemergence of morale as a target category along with industrial and military installations.

Whatever else might be said of these raids, they offered the first clear indication that BDA was beginning to influence *how* the British bombed, rather than simply describing *how well* they bombed. Unfortunately, with respect to the latter, they continued to do poorly, particularly in their effort to hit “precision” targets such as oil plants, a fact made clear by increasing numbers of post-strike photos. Then, another crisis, brought on by German U-boats and surface raiders, intervened to divert British bombers from oil targets to German port cities in an effort to destroy as many German naval combatants and stores

⁸ See Middlebrook and Everitt, *Bomber Command War Diaries*, 124-130. Oil attacks included a 43-bomber raid on oil-storage tanks at Rotterdam the night of 10-11 February 1941, 44 bombers to Gelsenkirchen and 44 to Homburg on 14-15 February, 73 aircraft to Sterkrade Holten and another 70 to Homburg 15-16 February (the Homburg raid provided the first evidence that Peirse was also trying to apply Dewdney's ideas about concerted attacks on a given target until it was out of action). City attacks included the 222-bomber raid on Hannover 10-11 February, 79 bombers to Bremen 11-12 February, 34 to Wilhelmshaven 21-22 February, 80 to Düsseldorf 25-26 February, and then three major raids in quick succession on Cologne: 126 bombers on 26-27 February, 131 on 1-2 March, and 71 on 3-4 March 1940.

as possible.⁹ Although Air Chief Marshal Portal complained that the Admiralty had made "a mess" for the RAF with this diversion of effort to assist with the intensifying Battle of the Atlantic, two historians of British bombing noted that

it was in effect the Admiralty which had got the Air Ministry out of the 'mess,' for if Bomber Command had, at this stage, been left free to carry out the oil plan it would probably have done a great deal more damage to its prestige than to its targets. As it was, the Air Staff were given an opportunity to reconsider their plans for the offensive, and when the conditions for resuming it once more returned very different counsels were seen to prevail.¹⁰

Indeed, circumstances made a return to oil impractical and undesirable after March 1941. One of the biggest contributing factors was the German conquest of Greece the following month, which took the Ploesti option off the table. Another was the continuing British habit of spreading their bomber force too thin, this time by adding attacks on transportation assets in the Ruhr to oil and naval targets. A third, and vital, factor was the gradually increasing success of bombing raids on German cities. Ironically, these attacks increased in number dramatically as a result of Bomber Command's new orders to assist with the Battle of the Atlantic. This effort included a number of large raids on port cities such as Hamburg, Bremen, Wilhelmshaven, and Kiel, and major U-boat bases in France such as Brest and Lorient. Two large raids on Kiel (7-8 and 8-9 April 1941) caused the greatest damage to date, all of it clearly visible on aerial photographs of excellent quality. This convinced Portal, already sour on the oil campaign, that city bombing represented the only near-term operational hope for Bomber Command.¹¹

⁹ This effort, directed by Churchill, sought to take pressure off of the merchant fleet and their navy escorts.

¹⁰ Webster and Frankland, *Strategic Air Offensive*, Vol. I, 165-66. It is also important to remember that ineffective British bombing of oil targets early in the war, and the ending of these attacks in 1941, made the Germans complacent about dispersing, hardening, and better defending their oil-producing assets. This worked to the Allies' advantage in 1944-45.

¹¹ See CAB 84/3/7, Industrial Target Report No. 14, 12 January 1941.

When Lord Hankey, whose committees were in charge of tracking the German oil position, pressed for a continuing attack on oil, Portal demurred, stating that “any diversion on to oil targets would result in complete waste of bombing effort and would, from the strategic aspect, be quite unjustifiable.”¹² The increasing quantity of good BDA reports played a key role here. Portal continued with an observation that it was “it was useless to attack pin-point targets such as the synthetic oil plants except on clear moonlight nights of which there were an average of only four per month.” Another sign that Portal was turning increasingly to city bombing was his statement that bombs dropped wide of oil targets were largely wasted because many German oil plants and refineries were outside of major cities. This idea that bombs dropped on cities would always have a positive effect of some kind was rapidly taking hold among British airmen. Finally, Portal was discouraged by the estimate—too *high* as it turned out—that attacks on German oil targets during 1940 had only reduced output by some 5 percent, mostly because bombing accuracy had been so poor. Portal ended with a reluctant and crucial recognition that “Although the destruction of synthetic oil plants was strategically desirable, they were not objectives which were tactically vulnerable.”¹³ The only alternative, he said, was to make one or two large-scale raids on oil targets per month, when weather and moon conditions permitted, but otherwise to concentrate on attacking transportation and morale in western Germany. The following week, he rejected firmly and finally Hankey’s plea to continue the oil campaign.¹⁴

¹² AIR 8/1016, COS (41) 245, 14 July 1941, 1.

¹³ Ibid., 2.

¹⁴ Ibid., 3; AIR 8/1016, COS (41) 144, 15 July 1941, 2.

At the same time, Peirse was struggling with another serious concern: his inability to get as many useful post-strike photographs and damage assessments as he felt his staff needed to judge the effects of Bomber Command attacks. In a statement that can only be construed as both a request for manpower and a veiled attack on the CIU (until recently the PIU), which he felt was providing too few useful damage assessments, Peirse told the Secretary of State for Air:

At the present time my Intelligence staff does not possess the necessary technical and industrial qualifications to assess damage (or otherwise) which has accrued—even when photographs are available. Moreover when precise bombing is resorted to I need to estimate not only the most vulnerable points for attack but the likely weight of attack required for their destruction. To put it shortly I need the full time services on my Planning staff of a professional expert versed in the subject of German communications (Railways first and foremost) and preferably with a knowledge of the enemy's general industrial structure as well...It seems likely that my ultimate requirement will be for more than one industrial planner.¹⁵

Air Vice Marshal Norman Bottomley, recently made Deputy Chief of the Air Staff (DCAS), replied that the Air Ministry was willing to spare Mr. Brant of the Railroad Research Service on a part-time basis to assist with planning attacks on Ruhr transportation targets, but also noted that such experts, who were in very short supply, needed to be based in London so they could be in the best position to provide accurate and useful advice.¹⁶

Peirse was resolved to improve Bomber Command's Intelligence Directorate and enlarge it to the point where it would be capable of providing all the targeting, BDA, and MEA data required to maximize the effects and effectiveness of his aircrews' efforts. This decision was a result of Peirse's frustrations with the Air Ministry, which he felt

¹⁵ AIR 14/784, Memo, Peirse to Sinclair, 19 June 1941, 1-2.

¹⁶ AIR 14/784, Memo, Bottomley to Peirse, 30 June 1941, 1-2.

produced rudimentary target dossiers lacking detailed insights on industrial targets, and with the CIU, which he thought provided too few BDA reports—a problem soon to be resolved but at the time a major source of frustration. These concerns led Peirse to establish a large Bomber Command targeting, BDA, and MEA capability at first in competition with the CIU but later working in coordination with it. The division of labor brought on by this evolving relationship included Bomber Command Directorate of Intelligence responsibility for building detailed target dossiers with all available targeting material and CIU damage assessments. The CIU continued to produce post-strike BDA reports, sharing the assessment process for night raids with Bomber Command.¹⁷

By the summer of 1941 the PRUs and CIU were well on the way to maturity, and the quantity and quality of photographs and damage assessments were improving. The arrival of eight photointerpreters from Bomber Command to augment K (Damage) Section provided a major boost in experience, especially for the interpretation of night photographs. The Bomber Command Directorate of Intelligence had been pushing this process forward ever since the first night strike photos, produced by Bomber Command in May 1940, provided clues but also mysteries about the accuracy and effects of British bombing. During the year after these first photographs were produced, photointerpreters at Bomber Command and the CIU had worked hard to unlock their secrets. By the summer of 1941, they were able to determine where British bombs were falling, how German decoy fires were affecting bombing accuracy, and the degree to which the

¹⁷ See AIR 14/1210, Bomber Command, "Review of Work of Intelligence 1 Section (Target Intelligence & Damage Assessment) 1939-1945," 18 August 1945, 9-10. Although this report fixes the dates for these developments after Peirse's replacement by Air Chief Marshal Arthur Harris in January 1942, it is a biased document singing the praises of city bombing and, indirectly, Harris. Peirse is therefore entirely absent, as are these early initiatives, which actually began during his last few months as head of Bomber Command.

position of each aircraft in the bomber stream affected its bombing accuracy. The latter revealed a tendency for bombs to “creep back” from their aim points, a phenomenon in which, as fires spread, aircrews towards the back of the bomber stream bombed the leading edges of those fires, resulting in poor bombing accuracy. By February 1942, the CIU had established N (Night Photography) Section, dedicated to analyzing these photos to improve BDA techniques.¹⁸ Long before this, however, night strike photos and associated BDA reports had driven a change of fundamental importance in British bombing doctrine and operations, another case in which BDA reports influenced *how* the British bombed, not just *how well* they bombed.

The change in question was a rapid move toward night city bombing as the new Bomber Command operational doctrine. The pictures in question included several hundred night strike photos taken during missions in June-July 1941. Lord Cherwell, Churchill’s scientific advisor, who believed British bombing to be highly inaccurate, directed his secretary, Mr. D. M. B. Butt, to examine these photos and determine how badly aircrews were bombing. The Butt Report, published 18 August 1941, confirmed Cherwell’s worst fears. Butt found that of those aircraft actually attacking their targets, only one in three dropped its bombs within five miles of their aimpoints. When aircraft failing to bomb due to mechanical difficulties or weather aborts were included, the number dropped to one in five. There were also major variations in accuracy depending on the target’s location, the moon state, and the amount of industrial haze. The bombing of French ports proved easiest due to the contrast provided by the coastline. Two of three

¹⁸ AIR 34/84, Historical Report, “ACIU N (Night Photography) Section,” 26 September 1945, 1-2. The use of a night-strike camera synchronized with the bomber’s airspeed, when combined with flash bombs and later electric flashes, produced excellent photographs showing surface details with little or no blurring.

sorties bombed within five miles of these targets. Over Germany as a whole, one of four did so. The worst accuracy was against targets in the Ruhr, often covered by haze, where only one in ten sorties delivered bombs within five miles of the target. During full-moon periods, the figure was two in five, but during the new moon only one in fifteen.¹⁹

The report produced shock, anger, and a firm resolve to fix the problem. Bomber Command tried vainly to cast doubt on the report's findings by noting that the strike photos in question provided insights on only 10 percent of all Bomber Command missions flown in the June-July timeframe, and that the weather during both months was particularly bad. Still, everybody agreed that British bombing had arrived at a point of profound crisis.²⁰ Lord Cherwell, in a memo to Churchill summarizing the results of Butt's study, admitted that "It makes depressing reading."²¹ He went on to emphasize the "supreme importance of improving our navigational methods," pushing for the development of a target-marking capability embodied in what came to be known as Bomber Command's Pathfinder Force. This elite group of bomber crews, formed in August 1942, was specially trained to drop target-marking flares of various colors to guide the main striking forces to their targets. Cherwell also advocated the rapid development and fielding of Gee, a radio aid to bombing and navigation that allowed aircrews to drop their ordnance at the intersection of several radio beams coming from transmitting stations in Great Britain. Until the Germans jammed its signals in August 1942, Gee allowed British raids to concentrate their bombs around an aimpoint to an

¹⁹ AFHRA 512.041-26, Air Ministry, Air Historical Branch 1, *The RAF in the Bombing Offensive against Germany*, Vol. III, 41-43; Webster and Frankland, *Strategic Air Offensive*, Vol. IV, Appendix 13, 205-213; Hinsley et al, *British Intelligence*, Vol. 2, Part 1, 260-261.

²⁰ AIR 8/1356, Memo, "Brief Note by S.A.S.O. Bomber Command on Report by Mr. Butt, 30 August 1941, 1.

²¹ AIR 8/440, Minute, Cherwell to Churchill, Summary of Butt Report, 02 September 1941, 1.

unprecedented degree. Cherwell also played a role in another development arising from Mr. Butt's work: the creation of Bomber Command's Operational Research Section (ORS) in September 1941, charged with studying bombing accuracy and devising the tactical, navigational, and munitions innovations required to improve it.²²

As if the British did not already have enough bad news to digest, American air and naval attachés in Berlin sent the Air Ministry a report on the effects of British air raids against the capital of the Reich during summer 1941. Damage was very light, rapidly repaired, and still a novelty to the average Berliner. "Practically all observers are of the opinion," they continued, "that bombing accuracy has been poor and therefore military or industrial damage has been negligible."²³ Like Dewdney and virtually every other person with deep knowledge of British bombing, the attachés recommended that the British concentrate maximum force over the target in the minimum time, delivering the heaviest possible bomb load in the shortest possible period. They also favored concentration of effort on industrial targets, but, if this proved impractical, to go after German morale with heavy raids on densely built-up areas so visible evidence of attacks would be both ubiquitous and long-lasting.²⁴ If further proof of poor bombing accuracy was needed, this report provided it.

Churchill directed his ire at Portal, sending him a Minute regarding the Butt Report in which he stated simply: "This is a very serious paper, and seems to require your most urgent attention. I await your proposals for action."²⁵ When Portal responded that it

²² Ibid., 2-3; Hinsley et. al., *British Intelligence*, Vol. 2, Part 1, 261.

²³ AIR 14/1216, American Air and Naval Attaches to Air Ministry, "Effects of British Air Raids on Berlin," 22 September 1941, 3.

²⁴ Ibid., 4-5.

²⁵ AIR 8/1356, Minute, Churchill to Portal, 3 September 2005.

would take a force of 4,000 heavy bombers six months to destroy the German war economy, Churchill lashed out at him:

It is very disputable whether bombing by itself will be a decisive factor in the present war. On the contrary, all that we have learnt since the war began shows that its effects, both physical and moral, are greatly exaggerated. The most we can say is that it will be a heavy and I trust a seriously increasing annoyance.²⁶

The Chiefs of Staff added to this inter-office barrage with their argument that the weakest point in the German war machine was civilian morale, particularly industrial workers, who, Portal asserted with a particularly British ethnocentrism, were bound to be more susceptible than their British counterparts to sustained morale bombing.²⁷ Portal also reminded Churchill of the conclusion the Chiefs of Staff had reached that

It is in bombing, on a scale undreamed of in the last war, that we find the new weapon on which we must principally depend for the destruction of economic life and morale...After meeting the needs of our own security, therefore, we give to the heavy bomber fleet first priority in production, for only the heavy bomber can produce the conditions under which other offensive forces can be employed.²⁸

His next statement was revealing: Making the case for a major offensive against German cities, Portal said "The worst plan of all would be to continue our present preparations after we had ceased to believe in the efficacy of the bomber as a war-winning weapon."²⁹ Here was further indication of the unwavering belief that the bomber would eventually play a decisive role in the Allied victory. Portal won Churchill over and sent Bomber

²⁶ AIR 8/440, Minute, Churchill to Portal, 27 September 1941. Portal's note to Churchill on the requirement for 4,000 heavy bombers is at AIR 8/440, Minute, Portal to Churchill, 25 September 1941.

²⁷ AIR 8/440, Minutes, Portal to Churchill, 25 September 1941 and 2 October 1941.

²⁸ AIR 8/440, Minute, Portal to Churchill, 2 October 1941, 3. Note the Chiefs' emphasis that the heavy bomber was not a war-winning weapon in its own right, but rather one that could "produce the conditions under which other offensive forces can be employed." This was combined-arms thinking at its best.

²⁹ Ibid. This statement also appears, at first glance, to make Portal a bombing zealot who viewed the heavy bomber as a war-winning weapon in its own right. If he ever held this view, it changed during the course of the war, and by the spring of 1944 he believed firmly that bombers would not win the war alone, but rather facilitate a quicker and less costly victory by supporting Allied armies in the field with attacks on oil and transportation targets.

Command forth with a directive to destroy Germany's cities, and, in the process, wreck its war industries and civilian morale.

Two weeks after these exchanges between Churchill and Portal, Air Chief Marshal Peirse sent Portal a note emphasizing the difficulties of concentrating bombing raids in time and space, despite the vital importance of doing so for bombing effectiveness and defense against German flak and night fighters.³⁰ Having digested this memo, Portal sent Churchill a Minute in which he noted Bomber Command was "fully alive to the need for concentrating the maximum effective number of aircraft over a target in the shortest time so as to saturate the defenses." He then said

The bomber force has been going through a difficult transitional stage with the introduction of the new "heavies." Their numbers are building up. I am sure that, with the heavier weight of attack they represent, with the new navigational aids coming forward and, above all, with an improvement in the weather, the A.O.C.in.C. [Air Officer Commanding in Chief of Bomber Command] will soon be achieving his planned concentrations on an ever increasing scale.³¹

Portal's focus was on using these bombers in area incendiary raids, on a massive scale, against German cities, which he saw as the engines driving the Reich's war economy.

To give his bomber crews the tools they needed to make this vision an operational reality, Portal set Bomber Command and the RAF's chief scientists to devising tactics and technologies to make city-bombing effective. The development of Pathfinder Force was at the center of this effort. So, too, were marker beacons. By October, the Air Staff had initiated the development process for radio and pyrotechnic marker beacons. Concerns about German countermeasures forestalled the first option, but the development of colored flares with increased burn times proceeded rapidly. By 1942, scientists had

³⁰ AIR 14/1216, Memo, Peirse to Portal, 16 October 1941, 1-2.

³¹ AIR 14/1216, Minute, Portal to Churchill, 19 October 1941, 1-2.

increased burn times from three to seven minutes, giving the Pathfinders the tool they needed to light the way for the main body of each mission.³²

7.3 Air Intelligence and City Bombing: BDA Moves in a New Direction

The intelligence tools required to support the new bombing doctrine were also coming into place by 1942. The most fundamental one—good photographic cover of Germany's cities for targeting and BDA purposes—was already in place. With each reconnaissance sortie covering 3,000 square miles of territory, and with as many as 30 sorties per day photographing the Reich by this time, fairly complete cover was not long in coming. By September 1941, PRU1 had 37 Spitfires and two Mosquitoes attached. The former were capable of housing at most a camera with a 20" lens in their fuselage, but the latter could carry lenses up to 40" in length. This proved serendipitous as the F52 camera, which became operational in January 1942, carried a 36" lens and produced superb photos 8.5" x 7" in size from altitudes as high as 42,000 feet. Credit for this vital development belonged to Group Captain Laws, who had long pushed for it, and Harry Stringer at the Royal Aircraft Establishment, who designed and developed it. Photointerpreters at the CIU were deeply impressed by the greater "sharpness" and scale of these prints, which allowed them to see details invisible on earlier photographs.³³

Intelligence personnel at CIU's W (Photogrammetric and Drawing) Section employed these pictures to develop photogrammetric plans of over 500 cities and towns in Germany as well as diagrams of high-value targets such as oil plants, marshalling yards, factories, dams, and canal locks, all of which proved exceptionally valuable once

³² AIR 8/326, Memo, Air Ministry, "Development of Marker Beacons," 26 October 1941, 1-2.

³³ Nesbit, *Eyes of the RAF*, 121-122; Babington Smith, *Evidence in Camera*, 86-87.

these targets came under sustained attack. These products allowed the Air Ministry and Bomber Command to build excellent target folders. So exact were their measurements that photogrammetrists called their work "mathematical interpretation." Rapid production of detailed target materials, including Strategic Target Folders for city raids and Tactical Target Dossiers for point targets, became a reality in early 1942.³⁴

Aerial photographs from the F52 camera and 36" lens also revealed with great precision the many fire and building decoys the Germans had been constructing since mid-1941. The fire decoys imitated burning buildings to draw British bombers off of their targets, a practice that worked well until photointerpreters in CIU's Q (Enemy Decoys) Section began searching for them in earnest in July-August 1941. Once it became clear the Germans were engaged in this practice on a massive scale, the eight interpreters working in Q Section reviewed every archived photograph on file to locate decoys. In the process of analyzing night strike photos with N (Night) Section after August 1942, they discovered the Germans were also using rocket-launched and ground-based decoy marker flares to draw bombers away from flares dropped by Pathfinder Force. The upshot of these efforts was the development of better tactics, a more complex mix of colors for target-marking flares, and the ability to brief aircrews before each mission on the locations of German decoys, all of which led to better bombing.³⁵

³⁴ AIR 34/84, History, ACTU W (Photogrammetric and Drawing) Section, September 1945, 1-7; AIR 40/1816, Air Ministry, *Photographic Intelligence during the European War*, 30 June 1945, 20-21.

³⁵ AIR 34/84, History, ACTU Q (Enemy Decoys) Section, September 1945, 1-2. For a detailed look at the Q Section's efforts to locate decoys, see AIR 34/84, Interpretation Report No. Q.67., "Enemy Decoys and Their Function," 16 January 1943, and AIR 34/84, Interpretation Report No. Q.S.1., "Points Arising from the Study of Decoys during Recent Months," 6 November 1943. For a succinct look at German decoys, see Edward Westermann, "Hitting the Mark, but Missing the Target: Luftwaffe Deception Operations, 1939-1945," *War in History*, April 2003, 10 (2), 217.

As the quality of daytime photography increased in early 1942, so too did night strike photographs, which proved vital to the steady improvement in Bomber Command accuracy by allowing for better placement of target markers and permitting photointerpreters to plot the location of individual aircraft over the target area by their silhouettes against fires and clouds. And this in turn facilitated the assessment and correction of "creep back." This unconventional form of BDA proved vital because it provided the foundation for Bomber Command's parallel development of night area *and* precision bombing. The latter technique, little remembered now, ultimately resulted in a level of accuracy that allowed British aircrews to destroy the largest German synthetic oil plants in late 1944 and early 1945. This remarkable ability to bomb point targets at night had its origins in the formation of the CIU's N Section, which maintained a close association with its counterpart office in Bomber Command.³⁶

The first operational night photos produced by Bomber Command in May 1940 contained a confusing array of light patterns that did not divulge their secrets either rapidly or without a great deal of effort. The transfer of eight photointerpreters from Bomber Command to the CIU in September 1941 marked a watershed because these men were the most experienced in the RAF when it came to analysis of night photographs. They were incorporated into the new K (Damage Assessment) and N (Night Photography) Sections, where they brought their specialized skills to bear on the interpretation of night photos. These included the course and development of a given raid, the concentration of incendiaries and number required to cause major fires, the

³⁶ AIR 34/84, History, ACIU N (Night Photography) Section, 26 September 1945, 1-2. For additional insights on the process at maturity, see AIR 14/1229, Bomber Command Operational Research Section, "Statistical Assessment of the results of a Night Bombing Raid on a German Town using Night Photographic Evidence of the Distribution of Attack," 6 October 1943."

location and effectiveness of German decoys, and the location of German flak batteries and searchlights. In April 1942, they also began a cooperative effort with Bomber Command interpreters to produce rapid preliminary BDA reports, based on the plotting of fires visible in strike photographs. The Bomber Command Intelligence Directorate distributed these BDA reports to flying units within 24 to 48 hours, where intelligence officers and aircrews used them for mission planning as they prepared for further raids. This BDA plotting function was decentralized to the bomb group level in late 1942, but interpreters in N Section continued to produce second phase BDA and detailed analyses of the course and development of city attacks.³⁷

The formation of Pathfinder Force in August 1942, and subsequent improvements in bombing accuracy, imposed additional responsibilities on N Section. The much larger numbers of aircraft involved in night attacks after August 1942 produced greater numbers of strike photos, many of which lacked ground detail. In other words, these pictures recorded only fires and explosions on the ground, along with the distinctive light patterns made by flak and searchlights. In such cases, photointerpreters had to "plot by fires," which involved determining the position, in relation to the aimpoint, when aircraft released their bombs. The number of cases in which this proved necessary ballooned above 500 aircraft per mission on larger raids. Part and parcel of this process was a requirement to assess the course of each attack by the colored target-marking flares dropped by Pathfinder Force. This drove a need for color film, which was in use by late 1942 and comprised 80 percent of film in strike cameras by 1944. Once N Section and their Bomber Command counterparts completed this huge task, they sent their work for

³⁷ Ibid.

each raid to the Operational Research Section, where analysts determined the concentration achieved and the total bomb weight delivered on target.³⁸

The turn towards city bombing also had a major influence on the air intelligence process at Bomber Command, which found itself in the middle of a huge expansion in responsibilities related to assessing the effects of city raids. Once Air Chief Marshal Arthur Harris took charge of Bomber Command in February 1942, he promptly made the chief of his Photointerpretation Section, Squadron Leader Muir-Warden, "Target Advisor to the C-in-C" for the purpose of selecting the most lucrative city targets and developing detailed target materials for them. Muir-Warden and his subordinates had amassed a huge amount of information on German cities and put it to good use in coordination with the Int. 1. One of the key products turned out in this process was the town mosaic, both plain and annotated with aimpoints, which was updated for every raid and provided the basis for both target study and damage assessment. These mosaics were comprised of many aerial photos and covered the built-up areas of every German city.³⁹

By 1942, when city attacks began in earnest, night strike and post-strike BDA photos were available for every major raid. The intelligence drawn from them was crucial for determining the effects of raids, especially as Bomber Command Night Section and their CIU counterparts learned how to unlock the information hidden within night strike photos. When the shift to mixed payloads of incendiary bombs and "blockbusters" began in 1942, Bomber Command air intelligence personnel had the skills necessary to engage (in coordination with the newly-formed RE8) in very accurate assessments of bomb

³⁸ Ibid.

³⁹ AIR 14/1210, Bomber Command, "Review of Work of Intelligence 1 Section (Target Intelligence & Damage Assessment) 1939-1945," 18 August 1945, 1-8, 19. This document defined "built-up" areas as those where more than 40 percent of the earth's surface was covered by manmade structures.

damage to German cities. These studies, ultimately produced under an RE8 banner, included maps showing the relationship between building densities, construction types, and vulnerability to fire damage. They also noted damage to high-value industrial facilities within each town and the likely repair times required for each one.⁴⁰

Lübeck, bombed the night of 28-29 March 1942, was the first test case for the new bombing methods and, by extension, for the new BDA tools just described.⁴¹ The raid involved 234 bombers, including 26 of the new Short Sterling III four-engine bombers, each carrying 14,000 lbs. of bombs, and 21 Avro Manchesters, each with nearly 11,000 lbs. of bombs. In total, the raid dropped more than 400 tons of bombs. Good visibility, light defenses, and much-improved navigation skills resulted in accurate bombing, with as much as 50 percent of the bomb tonnage hitting the city, which was made largely of wooden timbers and thus highly flammable. Both night strike and post-strike photographs showed immense damage to the city, with approximately 190 acres, or 30 percent of the city's total built-up area, destroyed by the new mix of incendiary bombs and "Blockbusters." German sources captured after the war confirmed that over 2,400 buildings were destroyed or severely damaged and another 8,411 lightly damaged—in total comprising 62 percent of all buildings in Lübeck. Of these, 256 were industrial

⁴⁰ Ibid.

⁴¹ Lübeck and Rostock were the first two targets attacked using the new incendiary-and-Blockbuster combination. Both were medieval cities with tightly-packed central districts built largely of wood. They were therefore ideal targets for area bombing and were picked as test cases for precisely this reason. Harris knew he needed a dramatic success with which to begin his city-bombing campaign, and the attacks on Lübeck and Rostock gave him two. He was thus able to convince his bosses to approve a concerted effort. However, once the British began bombing newer cities built largely of concrete and brick, such as Berlin, their efforts proved much less successful.

concerns, including the Drägerwerke factory, which made oxygen equipment for U-boats and was totally destroyed. It was a successful opening gambit for city bombing.⁴²

The success of this first major incendiary raid was like a tonic to Churchill and Cherwell, and to the long-suffering leadership at the Air Ministry. The earlier atmosphere of gloom and pessimism was replaced by one of optimism, in which all things once again seemed possible with the rapidly-growing number of heavy bombers. Cherwell sent an upbeat note to Churchill on 30 March estimating that projected annual heavy bomber production by mid-1943 (10,000 aircraft) would provide the weight of attack needed to destroy Germany's 58 largest cities, which housed 22 million people. He expressed the view that such an attack "would break the spirit of the people."⁴³ The Prime Minister, moved again to optimism by BDA reports on the Lübeck raid, asked Cherwell what needed to be done to expand the scale and destructiveness of city raids even further by 1943. Cherwell replied that blind-bombing apparatus such as Gee and H2S, the first radar useful for navigation and target location, were of vital importance and had to be made widely available. In addition, navigation skills and new technologies sufficient to allow bombing in any weather were indispensable. Finally, he said the development of high charge-to-weight-ratio bombs such as the new 4,000-lb. "Blockbuster" and incendiaries must continue.⁴⁴

Sir Archibald Sinclair, Secretary of State for Air, supported Cherwell's recommendations in a note to Churchill, applauding the huge increase in accuracy achieved during the Lübeck raid. He pressed the Prime Minister to continue his support

⁴² Middlebrook and Everitt, *Bomber Command War Diaries*, 251-252.

⁴³ AIR 8/440, Minute, Cherwell to Churchill, 30 March 1942.

⁴⁴ AIR 8/440, Minute, Cherwell to Churchill, 5 April 1942.

of the bombing offensive and pleaded for as few diversions from the city-bombing effort as possible. Sinclair concluded with the hopeful thought that "we see no reason to doubt that within eighteen months and with American help the degree of destruction which Lord Cherwell suggests is possible can in fact be achieved."⁴⁵

These policymakers began to hope that Harris had hit upon the right doctrine and tactics to destroy German cities, and therefore industrial production and civilian morale. It was a hope at first nurtured by accurate BDA reports and, ironically, later dashed by them. They also believed, incorrectly, that the Americans would join the city-bombing effort. Finally, their mistaken belief that the German war economy was fully mobilized led them to conclude that British bombing could undermine the German war effort. In fact, there was much more "slack" in the economy than they realized, and this fundamental error in assessment would have serious consequences for the course and effectiveness of British bombing. So, too, would the unforeseen German capacity for dispersing the majority of their war industries, with the notable exception of oil plants and refineries, which remained vulnerable.

In addition, Sir Henry Tizard, Britain's chief scientist, believed Cherwell's assumptions were far too optimistic. Aside from the bomber production figure, which he thought far too high, Tizard questioned Cherwell's assertion that the 58 cities in question would be easy to find and destroy. He also found the estimate that each bomber produced would fly an average of 14 sorties during its service life overly optimistic based on loss rates to date. Tizard concluded that it would be impossible for Bomber Command to achieve decisive results by mid-1943, and that such results would not be possible until

⁴⁵ AIR 8/440, Minute, Sinclair to Churchill, 6 April 1942.

a much larger bomber force took the field. Tizard's note to Sinclair and Cherwell containing these concerns sounded a cautionary note that was, unfortunately, ignored in the heady atmosphere at No. 10 Downing Street and the Air Ministry.⁴⁶

Despite the upbeat mood among British leaders, it is vitally important to recognize that Churchill, even in his enthusiasm for Harris's city bombing, never lost sight of the fact that bombing was unlikely to prove decisive in its own right. "We must," he said,

regard the Bomber offensive against Germany at least as a feature in breaking her war-will second only to the largest military operations which can be conducted on the Continent until that war-will is broken. Renewed, intense efforts should be made by the Allies to develop during the winter and onwards ever-growing, ever more accurate and ever more far-ranging Bomber attacks on Germany. *In this way alone can we prepare the conditions which will be favourable to the major military operations on which we are resolved.*⁴⁷

Churchill, like Roosevelt and the Combined Chiefs of Staff, viewed bombing as part of a combined-arms team that would both speed the final victory and make it significantly less costly in blood and treasure. Perhaps the only senior Allied military leader who truly believed that bombing could win the war by itself was Harris, who remarked to Portal on 3 September 1942, when Bomber Command attacks appeared to be getting steadily more effective, that a concerted bombing campaign could end the war in a year, but that any other means of achieving victory would take several years. Harris proved the exception to the rule, and he proved to be wrong.⁴⁸

In the meantime, however, Harris decided to attempt a second major bombing coup with a series of four raids on another Baltic port town, Rostock, which like Lübeck was

⁴⁶ Memo, Tizard to Sinclair and Cherwell, 20 Apr 1942, quoted in Webster and Frankland, *Strategic Air Offensive*, Vol. I, 333-334.

⁴⁷ Winston Churchill, *The Second World War*, Vol. IV, (Boston, MA: Houghton Mifflin Co., 1985), 783-784. Emphasis added.

⁴⁸ AIR 8/424, Memo, Harris to Portal, 3 September 1942.

also a medieval city built largely of wood and thus highly vulnerable to incendiary bombing. The first attack, on 23-24 April, was unsuccessful, with most crews dropping their bombs between two and six miles from the aimpoint at the city's center. From there, however, raids on 24-25 April, 25-26 April, and 26-27 April, each by over 100 aircraft, did increasingly severe damage. By the time the dust settled and the fires went out, nearly 2,300 buildings were destroyed or severely damaged, and 60 percent of the town was burnt out. Once again, aerial photographs confirmed the damage and allowed photointerpreters to conduct detailed analyses of the effects of these four raids.⁴⁹

With Bomber Command now committed to an incendiary war against German towns, Harris and his subordinates placed great emphasis on the development of bombing tactics, techniques, and navigational aids. The Intelligence Directorate expanded as BDA reports, far from providing mere photographic interpretation and written analysis, began to influence the selection of future targets. As German towns came under sustained attack, damage assessments produced at CIU's K Section and at Bomber Command's Intelligence 1 (Target Intelligence and Damage Assessment) Section (designated Int. 1) told Bomber Command's senior airmen whether a town required immediate follow-up attacks or was so heavily damaged that the bomber force could move on to the next objective. To assist with this process, Int. 1 built an Industrial Card Index from which specific information on industries and the towns where they were located could be accessed quickly. This detailed information came from MEW, CIU, and the Air Staff. From there, Int. 1 built photo mosaics of all major German and Italian cities with all high-value targets highlighted. The CIU provided all the photos for this massive effort, which

⁴⁹ Middlebrook and Everitt, *Bomber Command War Diaries*, 259-261.

was well underway by the end of 1941. At the same time, Int.1 built Town Dossiers for every major town, including all available information of interest to Int.1's targets and BDA officers. Finally, Int.1 determined whether the concentration and scale of each attack merited photoreconnaissance cover for BDA purposes. If so, a request went to ADI(Ph) and from there to the PRUs for collection of aerial photographs and to CIU K and N Sections for the production of Immediate and Detailed Interpretation Reports.⁵⁰ These new procedures were soon put to the test during the largest attacks yet made on German cities: the thousand-plane raids of spring and summer 1942.

The first thousand-bomber raid, against Cologne on 30-31 May 1942, was a shock to the Germans and boosted British morale. Several major tactical innovations made the bombing exceptionally accurate and concentrated, a fact borne out by a large number of excellent night-strike and post-strike BDA photographs as well as detailed CIU K Section reports and city damage mosaics and maps. First, Harris employed his concept of a "bomber stream" in which all bombers flew by a common route and at the same speed to and from the target. In addition, Gee and Pathfinder Force made it much easier for the bomber stream to locate and concentrate on the target. Where four hours had been allotted the previous year for 100-bomber raids and two hours for the 234 aircraft that attacked Lübeck on 28-29 March, only 90 minutes were required for just over 1,000 bombers to attack Cologne. Ultimately, this figure was reduced even further, to less than 20 minutes for an attacking force of similar size. Interpreters determined that over 5,400 buildings were destroyed or severely damaged, including 36 large factories that had a

⁵⁰ AIR 14/1210, Bomber Command, "Review of Work of Intelligence 1 Section (Target Intelligence & Damage Assessment) 1939-1945," 18 August 1945, 9-10.

complete loss of production, 70 suffering a 50-80 percent loss for up to three months, and another 222 suffering up to a 50 percent loss. There was an important cautionary note as well: An MEW report issued on 18 July noted that repairs were made much more quickly than had been expected, indicating a well-organized repair and reconstitution effort.⁵¹

Also troubling was the fact that these impressive damage figures masked several serious BDA deficiencies regarding city attacks. First and foremost was incomplete knowledge of what, exactly, British bombs were destroying. For instance, although later BDA reports determined that over 250 German factories were destroyed or damaged during this raid, air intelligence personnel only knew what was being produced in 50 of them. What the others were up to was a mystery.⁵² Also troubling was the impossibility of determining what photointerpreters called “invisible damage”: the machine tools and other equipment destroyed inside factory buildings but not visible due to their being covered by largely intact roofs. Even more distressing, as the raids continued, was an inability to come up with quantitative and qualitative measures for determining the degree to which each raid had damaged the larger German war effort. Aside from the fact that such calculations were based on an inaccurate assessment that the German economy was already fully mobilized, convincing measures of merit were elusive. Inevitably, BDA reports focused increasingly on morale, the rate of repair work, the costs of refugee services, and other difficult-to-measure aspects of bomb damage.⁵³

⁵¹ FO 935/119, MEW, Industrial Damage Report, 4 July 1942; FO 935/119, MEW, Industrial Damage Report, 18 July 1942; AFHRA 512.041-26, Air Ministry, Air Historical Branch 1, *The RAF in the Bombing Offensive against Germany*, Vol. IV, 171-173; Middlebrook and Everitt, *Bomber Command War Diaries*, 271-272.

⁵² AIR 8/833, Memo, Portal to Harris, 27 April 1943.

⁵³ AIR 34/85, Air Ministry, “The Work of A.I.3(c)2” (Produced for Air Intelligence Handbook—Part IV), 20 July 1945,” 3-5.

By July 1942, concerns about this lack of clarity in damage assessments drove several key developments. The first was a meeting between A.I.3(e), the Air Ministry office responsible for aggregate damage assessments, the CIU commander, and Bomber Command's Chief Intelligence Officer, in which they discussed establishing a formula for estimating "invisible damage." Bomber Command's intelligence chief deemed the meeting a failure and called for the formation of a committee of photointerpreters, scientists, statisticians, and civil engineers to devise a workable formula. The solutions arrived at, addressed in the following chapter, brought greater precision to measuring the physical effects of bombing and even pretended to do so for the purposes of assessing morale effects, but in the final analysis they proved unable to provide a comprehensive or confident measure.⁵⁴ Part and parcel of these efforts, however, was the creation of a new office at the Ministry of Home Security—Research and Experiments Department 8 (RE8). Along with MEW and the CIU, RE8 played a leading role in the BDA process once established in November 1941. It proved capable of providing detailed BDA of the sort desired by Bomber Command, but also produced outstanding BDA on American daylight precision attacks once they began in August 1942. In this sense, the creation of RE8 was a watershed event in the development of Anglo-American BDA capabilities.

7.4 Organizational Innovation: RE8 and Detailed BDA Reports

The Ministry of Home Security formed RE8 at the request of the Air Ministry, which recognized the requirement for a new organization to conduct scientific analysis of

⁵⁴ AIR 14/1216, Minute, Air Ministry Deputy Chief Intelligence Officer 3 (DDI3) to Chief Intelligence Officer Bomber Command (CIOBC), ADI(Ph), and AI3(e), 4 July 1942; AIR 14/1216, Minute, CIOBC to DDI3, 6 July 1942.

enemy target vulnerabilities and the effects of bombing raids on German cities and industrial facilities. With its expansion in July 1942, Squadron Leader Dewdney assumed the leadership position from Professor J. D. Bernal. Dewdney was the intelligence analyst who, while working at Bomber Command, had pioneered the use of Ministry of Home Defense damage assessments of German raids on British industrial facilities. He had also spearheaded the use of operational research techniques to determine the weight of attack, bombing tactics, and munitions required to inflict the greatest damage on the German oil industry. Once in his leadership role at RE8, Dewdney continued to push the development of these BDA-related skills as the executive officer of a committee formed to refine the theory and practice of the RAF's operational research efforts. Along the same lines, Dewdney created an advisory group consisting of RE8's senior scientific advisors and officers to provide advice on bombing techniques and the expected results. The Air Staff, Bomber command, and 8th Air Force valued RE8 products and used them extensively.⁵⁵

Under Dewdney's leadership, analysts at RE8 soon began producing four key assessments: *Town Reports*, which included a comparison of reported and actual bombs on target, bomb distribution, and estimated damage to industrial and non-industrial zones; *Installation Reports*, which looked at a single high-value factory or other facility, noting bomb count and distribution, structural damage, and impact on production; *Weapon Reports*, which provided detailed MEA of various bombs and fuses employed against all target types; and *Repair and Reconstruction Reports*, which tracked the rate at which Germans brought their factories back on line. These reports were built on a foundation

⁵⁵ HO 191/203, Air Ministry RE8, "History of the Research and Experiments Department," 1945, 7-10."

provided by the vast quantity of CIU K and N Section damage assessments as well as the tens of thousands of photographs upon which all these reports depended. Consequently, RE8 products took several weeks to compile and soon became the *sine qua non* of BDA reports. Once RE8 reports were complete, the authors met with their MEW counterparts to assess the aggregate impact of Bomber Command and 8th Air Force attacks on the German war economy. MEW then released quarterly, semi-annual, and annual reports on the economic impacts of bombing, in the aggregate and by specific industry.⁵⁶

One of the reasons for the great precision and accuracy of RE8 reports was their authors' comparison of precisely measured damage to British towns from German air raids with BDA data collected for Allied bombing raids. This comparative approach provided a means for determining damage to German structures and the associated loss of production. It included insights on damage to buildings of various types caused by German bombs; comparisons of the characteristics of those bombs with British bombs of similar size; the susceptibility of various industries to blast, fragmentation, and fire damage; comparisons of British and German building construction with a view towards optimizing bomb choice; and assessments of railroad damage and delays in traffic. This was another reason RE8 reports became the gold standard, particularly once ground survey teams in France and Germany during 1944-45 determined that RE8 reports were always within a few percentage points of figures quoted in German damage records.⁵⁷

⁵⁶ Spaatz Box 186, "Brief Outline of Research and Experiments Department, Ministry of Home Security," n.d. but probably July or August 1943, 1-2. Weapon Reports receive greater attention later in this chapter.

⁵⁷ Ibid., 2-3. Just how accurate these assessments became is evident in HO 191/120, RE8, "Comparison of Aachen Records of Effects of Air Attack with Estimates Derived from Aerial Photographs and with Allied Official Records of Attacks and Weapons Used," 29 March 1945. This report, which covered the period 15 July 1943 to 19 April 1944, provided German and RE8 figures on bomb damage for comparative purposes. They were: Housing units destroyed: German 21,200 / RE8 19,500; Housing units seriously damaged:

The BDA analysts working in RE8 from its formation in November 1941 and expansion in July 1942, including not only Dewdney, but also the two chief scientific advisors, Professors J. D. Bernal and Solly Zuckerman, would soon employ BDA reports to drive major changes in focus for Allied bombing in 1944-45, including the two transportation offensives in France and against the Reich. They had connections with British plant managers, engineers, and architects who advised them on various aspects of BDA and MEA, drawing on their own expertise and their experiences with the German bombing of British plant and equipment. This close-knit network of subject-matter experts proved central to the production of effective RE8 reports.⁵⁸

Despite some friction at the outset between RE8 and the CIU over their appropriate relationship and the point at which one's work stopped and the other's began, an Air Ministry officer summed up the potential value and importance of the relationship:

I think that R.E.8 are doing useful work in that they are examining certain of our raids on Germany in very much greater detail than C.I.U. can possibly do. They are in fact doing a sort of 4th phase interpretation and should begin where C.I.U. leave off. They examine the photographs not only from the point of view of assessing the damage, but they examine in great detail, house by house, to see what lessons can be learnt as to the effects of various methods of attack and various types of bombs, both H.E. and incendiary. In this part of the work, the Ministry of Home Security's detailed knowledge of what happened in this country [as a result of German bombing] is of the greatest value. D.B.Ops. [the Air Ministry's Director of Bombing Operations] thinks the results so far obtained are promising, and is anxious that the work should continue.⁵⁹

German 9,600 / RE8 9,500; Total dwelling units uninhabitable: German 30,800 / RE8 29,000; Persons made homeless: German 30,000 / RE8 28,100; and Persons killed (13/14 April 1944 attack only): German 1,520 / RE8 1,350. This remarkable accuracy allowed the British to estimate the aggregate economic and demographic impacts of their city raids, and even the larger impacts on Germany's war effort, but the latter proved impossible to determine with any precision. The reasons for this were complex and receive detailed attention in Chapter 8.

⁵⁸ AIR 40/1171, RE8, "Utilisation of P.R. by Min. Home Security, Research and Experiments RE8," 24 September 1943.

⁵⁹ AIR 40/2025, Memo, AI3(c)(Air Liaison) to DDI3, Air Ministry, "C.I.U. and R.E.8," 27 October 1942, 2-3.

The upshot of this recommendation that RE8 and CIU work closely together was a formal liaison function between Squadron Leader Dewdney of RE8 and Squadron Leader Tilling of the C.I.U. Together, they developed procedures for effective coordination between the two organizations and, in turn, worked closely with their Bomber Command counterparts to establish an effective damage assessment methodology for determining the effects of bombing raids on German cities.

The impetus for this effort had its origins in Bomber Command's concern that there was no clear method in place for determining the damage done to German cities or for compiling this information. Bomber Command's Chief Intelligence Officer complained that "There is at present no dossier in existence in which intelligence about the effects of our bombing is collated for each of the main German town targets...the full machinery of intelligence is not being directed towards assisting in the selection of targets."⁶⁰ He emphasized that closer collaboration with MEW was required to determine the economic effects of attacks, with the Political Warfare Section for assessing morale effects, and with RE8 for detailed damage assessments of different portions of cities and specific factories. To address these shortcomings, he directed Int.1 to work with the CIU, RE8, and MEW to develop what came to be known as Damage Dossiers for each city target. These were designed to provide a summary of damage to date, rate of recovery, and the relative value of attacks in terms of damage to the enemy's war effort. The object was to create a capability to employ the cumulative BDA in these dossiers to make decisions about future attacks and aimpoints for each target. They were designed to allow for a rapid assessment of the relative value of each target, based on current damage level, in

⁶⁰ AIR 14/1216, Minute, CIOBC to Harris, 23 December 1942.

comparison with those of other cities, to determine which should have priority for the next round of bombing raids.⁶¹

The dossiers consisted of an analysis of the bomber force employed in each raid, the bomb load carried, and the “effective” percentage of bomb load (the percentage actually falling on the target). They also contained a keyed damage plot showing damage distribution in industrial and residential areas, with individual damage assessments for the most important factories. “Domestic damage,” including the estimated numbers of civilians killed, wounded, and de-housed, also received a place in the dossiers, as did graphs showing the drop in output of various types of industry resulting from each raid and estimated recovery rates and times. A “Strategical Index” showed the town’s assessed value based on a Key Point Rating expressed as fraction of Germany’s assessed total war effort. This included a running tally of the drop in the town’s value due to attacks, and its subsequent rise as repair efforts progressed. The “Strategical Index” thus comprised the heart of the Damage Dossiers. There was also an assessment of the enemy’s expenditure of military resources in defense of the target, including aircraft and flak wastage and use rates, ammunition and fuel consumption estimates, and other costs of air defense. Finally, there was an assessment of “imponderables,” including morale.⁶²

The key players in this effort met to determine the *process* by which they would divide the workload and share BDA data to maximize the effectiveness and efficiency of

⁶¹ AIR 14/1216, Minute, CIOBC to Harris, 23 December 1942; AIR 14/1216, CIOBC, “Preliminary Notes on Compiling Damage Dossiers,” 20 January 1943, 1-2; AIR 14/1216, CIOBC, “Aim of Damage Assessment System,” December 1942. Although Damage Dossiers did not become operational until early 1943, the process for developing and structuring them, and discussions between Bomber Command, the CIU, RE8, and MEW as to what each organization would contribute, began in the fall of 1942.

⁶² AIR 14/1216, CIOBC, “Preliminary Notes on Compiling Damage Dossiers,” 20 January 1943, 1-2; AIR 14/1216, CIOBC, “Aim of Damage Assessment System,” December 1942.

the Damage Dossier process. As a launching point for this effort, Squadron Leader Dewdney used the first detailed RE8 damage assessment, produced for two attacks on Düsseldorf in August-September 1942, to discuss his ideas about the ideal methodology for producing Damage Dossiers. He noted that the RE8 process employed for this assessment allowed analysts to determine that 19 percent of bombs dropped fell within the built-up area of Düsseldorf and that the direct economic effects of the attack equaled about 4 percent of one day's total war production for Germany. The report also noted that the city reached normal output again by mid-October. Per ton of bombs dropped, incendiaries did three times more damage than high-explosives. Finally, Dewdney noted that the report was based on reconnaissance cover that included 100 percent of the city's residential areas, 64 percent of its industries, and 76 percent of its marshalling yards.⁶³

Dewdney next explained the process RE8 had developed to produce this detailed BDA for each raid, which included superimposing a grid on 1:5,000 scale photos and then making a building-by-building inspection of damage and assigning each building a color and shading pattern to denote the type of building (residential, commercial, or industrial) and the nature of the damage (blast, fire, or both). From there, analysts calculated the total damage inflicted in thousands of square feet, thousands of cubic feet, and man-hours lost. All attendees agreed that man-hours lost should be divided into those lost through direct damage (factory closures), by diversion of workers to repairs, and to indirect effects (absenteeism). Dewdney emphasized that the CIU would have to take over this process because RE8 lacked the manpower to do it on a permanent basis.

⁶³ HO 191/116, RE8, "Joint Report by R.E. 8 Ministry of Home Security and E. I. 2, Ministry of Economic Warfare, Summary, Düsseldorf, Raids of August 15/16 1942 and September 10/11 1942," October 1942, 1-2.

All agreed that CIU should do this. The MEW representative commented that he and his colleagues viewed the RE8 process as a huge improvement over previous methods for calculating BDA, and that MEW would now be able to express the effects of a raid in terms of the percentage loss of productivity for a city as a whole, and possibly also to measure loss of productivity for various kinds of industries within a given city. From there, MEW would supply Bomber Command Int.1 with figures showing the relative importance of various industries in each city, the total percentage of enemy war effort represented by that city (expressed in MEW's Key Point Rating system), and the losses due to bombing by industry type, by city, and as a percentage of the Reich's estimated war effort. Finally, upon receipt of RE8's man-hour loss assessments for a city, MEW would then supply Bomber Command Int. 1 with the new, reduced percentage figures for the various industries and the town's adjusted total contribution to the German war effort. MEW would also provide expected recovery time for each city attacked.⁶⁴

Once attendees agreed on the division of labor, all that remained was to iron out the details of the process for producing and updating Bomber Command's Damage Dossiers. They settled on a 10-step process designed to be complete 14 days after a given bombing raid. It began with CIU's K (Damage Assessment) Section. Each step took one or two days and looked like this:

1. CIU K Section prepared the 1:5,000 scale prints with grid overlay.
2. CIU K Section noted building types damaged (residential, commercial, and industrial) and the cause of damage (blast, fire, or both) on the 1:5,000 maps.
3. CIU K Section prepared a detailed bomb plot showing all known bomb impacts in built-up areas of the city.

⁶⁴ AIR 14/1216, RE8, "Notes of Meeting Held on 30.1.43. at Princes Risborough to Discuss Some Aspects of Damage Assessment System," 30 January 1943, 1-2.

4. CIU K Section traced and measured areas of damage and noted the zone boundaries (dividing lines between residential, commercial, and industrial areas of the city) on the 1:5,000 scale photographs.
5. RE8 confirmed damage by building categories and type, placing all damage data on punch cards for future reference (an indication they were using early computers to do some of their data-processing and statistical work).
6. RE8 estimated damage to utilities.
7. RE8 made adjustments in damage estimates for cloud cover and incomplete photographic coverage of the target area.
8. RE8 measured damage level in terms of lost man-hours.
9. MEW estimated the effect of the raid on the enemy's overall war effort.
10. RE8 circulated the finished report and Bomber Command Int. 1 built a new Damage Dossier or updated an existing one if a city had been attacked earlier.

The end results of this process were a comprehensive and sophisticated BDA report and a new or updated Damage Dossier that brought the BDA effort to the highest possible level of precision given the imponderables associated with BDA reports for city raids.⁶⁵

The problem with this approach, of course, was precisely its inability to adjust for these imponderables and pitfalls, of which there were many in the city-bombing campaign. One of the greatest, despite the obvious efforts put into quantifying it with the man-hours-lost process, was the degree to which city attacks disrupted industrial production and drew manpower away from productive work to debris clearance, repair, and reconstruction activities. The formulas RE8 came up with for determining this figure were quite intricate and might conceivably have been highly accurate except for five fundamental problems. The first of these was the Germans' lavish use of captive labor forces from the occupied lands, both as servile factory workers and as slave laborers for rubble clearance and other menial and dangerous tasks. There is no indication in any available sources that BDA experts were aware of this huge problem with the accuracy of

⁶⁵ AIR 14/1216, RE8, "Ministry of Home Security, Research and Experiments Department: Damage Assessment Method," February 1943.

their formula. Second, and nearly as important, was the rapid dispersal of factories, which began in late 1942 and accelerated in 1943. This allowed the Germans to reconstitute war-production facilities throughout the Reich, a process the Allies were not aware of until well into 1943. Third, the Germans were adept at continuing production in the basements and on the ground floors of buildings whose upper stories had been severely damaged by bombing. Allied photointerpreters got better at spotting the telltale signs of such activities as the war progressed, but the Germans stole many a march on them in this fashion. Fourth was the phenomenon of "invisible damage," touched on briefly before. This was the obverse of the Germans' ability to hide productive activities in damaged buildings because it meant the Allies were often unable to determine the damage they had done to machine tools and other high-value equipment. Fifth, and most important, was the maddening inability to determine with any precision how German morale fit into the larger BDA picture. British senior airmen and BDA specialists danced around this problem from the beginning of the war to its closing months and finally gave up, dejected, on the idea of either quantifying or breaking German morale. This acceptance of the fact that the German people and government were not about to capitulate because of "morale effects" came very late in the war and only after every possible means had been employed to avoid the truth.

In consequence of the British failure to take full account of these five issues, the sense of frustration in their BDA documents from the period 1943-44 is palpable. We can almost hear them asking why the Germans, who were clearly made of less stern stuff than their British enemies, refused to give up as their cities were burned to the ground and their homes and belongings and loved ones destroyed in these great conflagrations.

They seem simply to have missed the German civilian's great capacity for absorbing punishment and the Nazi leadership's fanatical determination to continue the war to the bitter end. This last point in particular—the iron control of the Nazi political and police apparatus over Germany—made the Allied search for decisive “morale effects” a will o' the wisp after which they followed, in vain and at their peril.

At the root of all these BDA-related analytical problems lay Harris's dogged determination to win the war with bombing alone. He was absolutely certain, even in the aftermath of Bomber Command's defeat in the Battle of Berlin from summer 1943 to spring 1944, that bombing could do it all. His beliefs on this score had a huge influence not only on bombing doctrine and operations, but, as we have seen, on the evolution of BDA capabilities as well. It is important to note, however, that Harris was by no means alone in the belief that bombing could have decisive results, if not on its own, then as part of an Anglo-American combined-arms effort. In 1942 and 1943, this in effect meant support for city bombing as the only effective means of taking the war to Germany and diverting scarce German resources from the battlefield. These included fighters and flak, more and more of which were held in the Reich and away from the fighting fronts as first the British and then the American bombing efforts got into high gear in 1942-43. If Harris's zealotry proved injurious to the bombing effort, his basic recognition that bombing could do grievous harm to the German war effort was on the mark, as we will see in subsequent chapters. Still, British BDA efforts in 1942-43 always had an air of fantasy that the perfect measures of merit for determining the effects and effectiveness of city-bombing would eventually show themselves, and a constant air of frustration when, month after month, they did not.

Nonetheless, it is vitally important to recognize that the process Anglo-American BDA specialists employed to determine damage to the German war effort ultimately paid huge dividends because it forced them to become experts in the art of assessing damage not only to cities as a whole, but also to *every component part* of those cities struck by Allied bombs. In other words, every oil plant, marshalling yard, viaduct, bridge, canal, and arms factory hit in the course of Bomber Command's 1942-43 city offensive received a detailed look and a damage assessment from photointerpreters at the various CIU sections and analysts at RE8 and MEW. The British also carried out a significant number of precision attacks during this period (although we tend to forget this), all of which lent themselves to detailed interpretation of specific facilities, as did the American precision raids that began in August 1942 with an attack on the Sotteville marshalling yard in the French city of Rouen. This ability to conduct detailed and exceptionally accurate BDA for specific high-value facilities proved vital once the bombing effort moved away from city attacks towards a renewed focus on specific target sets, including oil and transportation, in 1944-45. It would pay huge dividends in the 1944-45 bombing campaigns. So, too, would the serious attention the Allies gave to MEA as well as BDA. This effort resulted in the development of new bombs, fuses, and delivery techniques, all of which led to steadily greater bombing effects from late 1941 to the end of the war.

7.5 The Search for More Destructive Munitions: Better Bombs and Fuses

As the British bombing offensive moved slowly into high gear, significant improvements in bombs and fuses meant that British munitions, when delivered accurately, did much greater damage than the 250-lb. bombs in use at the start of the war. Efforts to develop effective bombs accelerated in late 1940, as evidence surfaced, mostly

in the form of BDA photographs and damage assessments, that 250-lb. bombs weren't cutting it when it came to attacking reinforced concrete structures. By October 1940, BDA reports made it clear that the 250-lb. bombs dropped on German factories were too small to cause serious damage.⁶⁶ The message got through too slowly. In September 1940, for instance, Bomber Command aircrews dropped 1,903 500-lb. bombs and 15,168 250-lb. bombs.⁶⁷ Even Churchill took an interest as evidence emerged of the 250-lb. bomb's ineffectiveness. In fact, he pushed his airmen to develop much larger munitions. Churchill's private secretary, Mr. R. S. Crawford, told the Chief of Air Staff at one point that "There has been considerable discussion on a high level with the Prime Minister regarding the use of large bombs including the 1000-lb. bomb."⁶⁸ The Chief replied that there were 190 of the new 1,000-lb. bombs filled and ready to drop.⁶⁹

However, because of the slow British start in manufacturing 1,000-lb. bombs, they turned to the United States for adequate supplies as their production ramped up. Tests of the American bombs revealed that the addition of British nose and tail fuses would make them effective against hardened structures such as reinforced concrete buildings.⁷⁰ Nonetheless, several officers noted that the move away from the 250-lb. bomb and towards the 1,000-lb. variety by no means meant the 500-lb. bomb was of diminished value. In fact, it was large enough to do serious damage, and in certain instances, including attacks on oil-storage depots, proved superior.⁷¹

⁶⁶ AIR 8/309, Minute, DCAS to CAS, 4 October 1940.

⁶⁷ AIR 8/308, Minute, Newall to Churchill, 14 October 1940.

⁶⁸ AIR 8/309, Minute, R. S. Crawford to Newall, 18 October 1940.

⁶⁹ AIR 8/309, Minute, Newall to Churchill, 16 October 1940.

⁷⁰ AIR 8/309, Minute, ACAS (T) to Portal, 16 November 1940; AIR 8/309, Memo, Wing Commander Odber to ACAS (T), 30 November 1940.

⁷¹ AIR 8/309, Minute, Crawford to Portal 1 November 1940.

At a meeting in December 1940 to discuss problems relating to bombs and fuses, attendees agreed at the outset that larger bombs were more effective, particularly against buildings and other hardened structures. A major shortcoming in the British arsenal was the fact that they had only hard-case bombs at the start of the war. The charge-to-weight ratio of these weapons was only 27 percent, the lowest of all bombs in use by the world's major air forces. This resulted in a proposal, adopted unanimously, to use a sheet metal bomb casing (rather than cast iron) and to increase the explosive charge to 35 percent of the bomb's total weight, yielding a very effective medium-case bomb. A new benzene-based explosive filling upped the charge by 12 percent and made filling bombs easier. It would soon be joined by RDX, an even more potent explosive. The higher charge-to-weight ratio of these new bombs, to be manufactured first in the 500-lb. and 1,000-lb. varieties and later in the exceptionally destructive 4,000-lb. "Blockbuster" version, produced dramatically higher blast damage and much larger craters, which disrupted utilities and made firefighting efforts more difficult by breaking underground electric lines and conduits, water mains, and sewage pipes. The plan for production of these new weapons was based on the early expenditure of American 1,000-lb. bombs, 580 of which had already arrived and were being equipped with British fins and fuses. The British preferred their fuses, believing them to be more reliable than the American varieties, an assertion that proved true once MEA on fuse performance became available in 1944-45. They were also satisfied with the five fuse types they had in stock, including two long delay variants: a 12-hour version and a variable 6-36-72-144-hour version. The key outcome of the meeting was a redoubled effort to produce large numbers of the new medium-case bombs beginning in 1941, an objective the British met. The new

generation of bombs, produced with sheet metal and without fins, resembled oil barrels more than aerial munitions. However ungainly their appearance, they became the primary agents of destruction, along with several effective incendiary bombs, in the attack on German cities.⁷²

Regardless of the successes resulting from this and subsequent meetings, Churchill was in no mood to let the RAF work without frequent reminders to develop effective munitions. Portal found himself constantly engaged with the Prime Minister on this issue. By January 1941, he was able to answer one of Churchill's queries about the continued use of 250-lb. bombs with the news that there had been a "big drop" in the expenditure of small munitions in attacks on Berlin, where the policy was to use the biggest available bombs. The turning point was November 1940, when 258 500-lb. bombs and only 59 250-lb. munitions were dropped on the Reich's capital.⁷³

By January 1941, Bomber Command was well on the way to building a master list of bombs and fuses, displayed in several tables, showing optimum bomb and fuse combinations for various targets including factory buildings, oil plants, and water and gas mains, to name but a few. One of the key conclusions noted in the memo accompanying these tables was that incendiaries caused much more damage in urban areas, especially if dropped in conjunction with large high-explosive bombs. The idea was to smash as many buildings and gas mains as possible, both of which were then more susceptible to ignition. In fact, the memo closed with a reminder that urban areas were particularly susceptible to fire damage, and that "Incendiary bombs should therefore be used in large

⁷² AIR 8/441, Minutes, Bombs and Fuses Meeting held on 6th December 1940, 7 December 1940, 1-4.

⁷³ AIR 8/440, Minute, Portal to Churchill, 3 January 1941, and attached Table, "Bombs dropped on Berlin."

quantities when attacking sea ports, inland water ports, and industrial towns.” These grim calculations provided the basis for all Bomber Command city attacks.⁷⁴

By February 1941 the Bombing Committee’s Bomb Sub-Committee was fully engaged with the problem of maximizing damage to high-value targets such as oil plants and was discussing the requirements for city-bombing. Professor J. D. Bernal of the Ministry of Home Security and later RE8 and brought to bear a great knowledge of the effects of German bombing on British cities and high-value industrial targets in 1940-41. Key decisions at this meeting included the employment of 1/40th second delay fuses and only 500-lb. and larger bombs for penetrating multistory buildings. Also, with respect to oil plants and refineries, all agreed that 250-lb. bombs with 4 lb. incendiary bomb follow-up would be most effective for destroying oil tanks, and that a certain proportion of 500-lb. and 1000-lb. bombs should be used to destroy larger buildings.⁷⁵

This slow but steady shift from smaller to larger bombs, and from precision to area targets, was evident in a variety of correspondence for this period, including an exchange of notes between Churchill and Portal regarding the optimum weapons for attacks on German cities. When the Prime Minister asked what was being done to expedite the development of large medium-case bombs and how they would be used, Portal replied that tests were underway to increase their stability in flight. As to their most appropriate use, he stated that “the best use of these bombs is for causing widespread damage in congested built-up areas in which the smaller and older types of workmen’s houses are

⁷⁴ AIR 8/441, “Memorandum by Bomber Command on Types of Bombs and Their Fusing,” January 1941.

⁷⁵ AIR 5/1142, “Minutes of the 25th Meeting of the Bombing Committee (Limited Attendance) at Air Ministry on February 5th 1941,” 13-17. The British later changed their tune on the 250-lb. bomb for oil plants, discarding it in favor of the 500-lb. bomb. In one of the great MEA failures of the war, American bombers went after oil targets with 250-lb. bombs for several months in 1944 before they bothered to ask the British what they were using.

concentrated adjoining industrial areas.”⁷⁶ Following as it did the discovery that incendiary bombs and high-explosive bombs used in combination could cause severe damage to urban areas, this note from the head of the RAF to the head of the British government confirmed that the handwriting was on the wall. There would be a major campaign against cities, and the means for their destruction would be medium-case “Blockbuster” bombs, ultimately weighing 4,000-lbs., and huge numbers of incendiaries.

In the meantime, Churchill had again exerted his influence in the bomb-development process to express his concerns that large numbers of bombs might be malfunctioning. This was the first sign that BDA reports based on aerial photographs were beginning to tell a tale nobody wanted to hear: that British bombing accuracy was poor. The first reaction to these reports was Churchill’s idea that the problem might be bad bombs rather than poor accuracy. Cherwell fired off a note to Portal saying the Prime Minister wanted a large-scale bomb test to ensure the bombs were not malfunctioning. Once the tests were complete, Portal delivered the “bad” news that British bombs in fact had a 91 percent detonation rate, which made them the most reliable then in use anywhere. Churchill did not have to wait long after this for the Butt Report to confirm his growing suspicion that bombing accuracy was the real culprit.⁷⁷

By January of 1942, the Bomb Sub-Committee of the Bombing Committee had a great deal of empirical evidence, gleaned from hundreds of BDA and MEA reports as well as bombing tests in the British Isles, upon which to base their decisions regarding bomb production. Among the most significant was the great utility of the 4,000-lb. hard-

⁷⁶ AIR 8/441, Minute, Portal to Churchill, 28 February 1941. This was in answer to Churchill’s Minute of 25 February 1941.

⁷⁷ AIR 8/440, Minute, Cherwell to Portal, 21 February 1941; AIR 8/440, Minute, Portal to Ismay, 7 April 1941.

case bomb against oil refineries. Its immense blast and cratering effects had the capacity to destroy both the above-ground steam pipes and the underground electric and gas utility conduits, which were vital for the effective functioning of oil plants and refineries. Equally important was the recognition by this point that 500-lb. medium-case bombs could be quite effective against oil tanks as well as marshalling yards. In fact, given the fact that they were nearly as effective as 1,000-lb. bombs, and that bombers could carry twice as many of them, they were the clear choice for attacks on these targets. Professor Bernal also recommended that 500-lb. bombs dropped on marshalling yards have variable fusing to slow down post-raid repair and reconstitution efforts. The British held that for attacks on oil plants, 500-lb. bombs, incendiaries, and 4,000-lb. bombs should be interspersed to smash piping and conduits, and to set afire any spilled oil or gasoline.⁷⁸

The remarkable thing about these conclusions, and the discussions that produced them, is that the British were already focused on city bombing by this time. Yet they continued to think seriously about the effects of various munitions against oil plants, marshalling yards, and other “precision” targets on which attacks had been abandoned as impracticable in early 1941 and which would not come under heavy attack for another *two years*. In the case of oil plants, many of Germany’s largest synthetic-oil producers were outside of urban areas and could not have been struck serendipitously by random bomb hits during the course of city raids. Destroying these oil plants would require dedicated, concerted, and large-scale attacks. We might then wonder why the British maintained a focus on the possibilities for attacking these targets and produced optimum

⁷⁸ AIR 5/1142, “Minutes of the 29th Meeting of the Bombing Committee, held at Air Ministry on June 12th, 1942.

munitions for them. Quite simply, British senior leaders never stopped believing that they would *eventually* have the means at their disposal to do grievous harm to these high-value target systems, and by 1944, with the Americans' arrival and the steady improvements in their own bombing force, they did.

Among the most important bomb-related developments during 1942 was the production of the 4,000-lb. "Blockbuster" bomb and several variants that would destroy German oil plants during the war's closing year. By July 1942 the 4,000-lb. bomb was approved for full-scale operational use and went to work immediately in Bomber Command raids on the Reich.⁷⁹

One thing even the 4,000-lb. heavy-case variant could not do, however, was penetrate the concrete U-boat shelters along the coast of France. Repeated attacks on the U-boat pens at Lorient, Brest, and elsewhere confirmed the invulnerability of the 11.5-foot-thick roofs. Even the best weapon then available in the American arsenal, the Navy's 1600 lb. AN-Mk 1 armor-piercing bomb, penetrated only 10.6 feet when dropped from 25,000 feet of altitude, which was too high for accurate bombing in any case. No British bombs could do the trick either.⁸⁰ However, given the importance assigned to U-boat targets both before and after the Combined Bomber Offensive directive of January 1943, American and British bombers continued to go after these targets even after it became clear that doing so would yield no meaningful results. It was a clear case of bombing to influence *Allied* morale, in this case positively, even though abundant BDA and MEA data made clear the futility of these missions in terms of effects and effectiveness.

⁷⁹ AIR 8/441, Minute, ACAS (T) to Portal, 20 July 1942.

⁸⁰ Spaatz Box 183, 8th Bomber Command Operations Research Section, Special Report No. 1, "Perforability of German Submarine Pens, Located at Lorient and Elsewhere, by American and British Aerial Bombs," 8 December 1942, 1-2.

Evidently, some things were so important as to make any insights gleaned from BDA, cautionary or otherwise, impossible to heed. American participation in these raids on German U-boat pens marked the first significant American effort and signaled the first serious involvement of U.S. intelligence personnel in the targeting and BDA processes.

7.6 The Yanks Arrive: Early Operations and BDA Integration

The first American air intelligence officers to arrive in Great Britain during the spring of 1942 were woefully under-trained by British standards but also proved themselves to be quick studies and quite capable of integrating into standing British air intelligence organizations. One of the great strengths of the Anglo-American BDA effort was in fact the willingness of the Americans to play the role of acolyte and, until the closing months of the war, work within an integrated and British-led BDA structure. The other great strength was the British willingness to teach the Americans everything they knew, treat them as equals in the business, and provide all of their BDA-related intelligence for American use. In addition, the operational combination of British “precision BDA” and American “precision bombardment” proved to be one of the most important and serendipitous aspects of a remarkably successful wartime cooperation.

This cooperation began, as we have seen, with visits by Majors Cabell and Hutchison to British photoreconnaissance and photointerpretation units in 1941. The recommendations they made based on these visits had a profound influence on the development of American BDA capabilities. The most important was for the formation of an USAAF photointerpreters’ school, which became part of the Army Air Forces Air Intelligence School (AAFAIS) in February 1942. In 1944 AAFAIS became the Intelligence Division, School of Applied Tactics, Orlando, Florida.

However, long before the new schoolhouse became operational, the first American photointerpreters were already learning the tricks of the trade from British experts. In August and October 1941, a total of nine American USAAF officers with photointerpretation experience arrived at the CIU to study in the various work sections, develop an understanding of CIU procedures as well as the latest interpretation capabilities and techniques, and carry this information back to the United States. They later played key roles at the Army Air Forces Air Intelligence School in developing its curriculum and working as instructors. By all accounts, British personnel at the CIU gave generously of their time and expertise to teach their American counterparts as much as possible in a short period of time. The fact that these American officers were able to gain largely unfettered access to the CIU, which was one of the most secret of British units, is impressive. The instruction they received from British photointerpreters is even more so and demonstrates how closely British and American air intelligence personnel were working together *before* the Americans became co-belligerents.⁸¹

After America's entry into the war, seven more USAAF officers arrived at the CIU in June 1942 to attend the four-week British Photointerpreters' School at RAF Nuneham Common and from there went to work for Colonel Robert Bacon, the 8th Air Force Chief Intelligence Officer (A-2). In August 1942, Bacon established The Provisional Photographic Interpretation Unit (PPIU). This American organization worked at the CIU under British tutelage in those offices the Americans and British agreed, mutually, would maximize the professional development of USAAF interpreters and provide the greatest

⁸¹ Spaatz Box 122, USSTAF, "History of Photo Intelligence in the U.K. insofar as it Pertains to British-American Cooperation," 22 May 1944, 1.

operational assistance to the CIU. By 30 September the PPIU had 16 officers assigned and another nine attached. At the same time, another 14 officers attended the British Photointerpreters' School at Nuneham Common. By the end of the year, the first 16 Yanks assigned to the PPIU had gained basic proficiency and were ready for operational assignments. The routine for getting U.S. photointerpreters up to speed once in theater was to place them in the four-week Nuneham Common course, then attach them to the CIU for a period of several weeks to build basic operational proficiency, and then send them to their operational units. As AAFAIS turned out more—and better—interpreters over time, fewer Americans took the British course at Nuneham Common, but there were always a few in every class until the end of the war.⁸²

These early American arrivals were soon joined by a much larger group of their countrymen when the 1st Photo Intelligence Detachment (1st PID) arrived in Great Britain on 13 January 1943. It consisted of 33 officers and 34 enlisted men, and the officers, all graduates of the Army Air Forces Air Intelligence School, nonetheless lacked the photointerpretation skills required to go directly into operational work. Consequently, Colonel Ordway, recently made 8th Air Force A-2, opened an American school for advanced photointerpretation work at RAF Pinetree and picked the most capable and experienced interpreters from the PPIU to teach the course. Students received “photograph after photograph,” all operational pictures provided by the CIU for training purposes, and wrote interpretation reports on them.⁸³

⁸² Ibid., 2-3.

⁸³ Ibid., 4.

One of the most important results of this process was an Anglo-American agreement that the 1st PID and its interpreters, once graduated from the new school, should stay at RAF Pinetree. There, they were joined just before D-Day by the members of K (Damage Assessment) Section, henceforth comprised of British and American photointerpreters. The rationale for this move was threefold. First, it placed K Section as close as possible to the British PRUs at RAF Benson and their American counterparts now arriving at RAF Mount Farm. Second, it allowed the 1st PID to provide the best possible support to American bombing operations and HQ 8th Air Force, which was also nearby. Third, it kept the Americans within the CIU orbit and under British tutelage, a key development the British and Americans agreed was appropriate and operationally necessary.

The two allies began coordinating their organizational relationships for BDA during a meeting between Flight Lieutenant Boggis, the Photo Intelligence Liaison Officer with 8th Bomber Command, and Major Horace W. Pote, the 8th Air Force's Assistant A-2 for Photographic Intelligence. The British confirmed that their PRUs had ample resources to handle American reconnaissance requirements, including all post-strike BDA sorties for 8th Air Force bombing raids. They also agreed to closer Anglo-American cooperation at the CIU. However, Boggis emphasized that the British were reluctant to see independent USAAF PRUs and an American CIU, a point on which Pote offered little comfort. He said American reconnaissance units would continue to arrive at Mount Farm and would play an increasing role in the collection of photointelligence, and he also intimated that an American CIU might stand up to provide a USAAF photointerpretation capability.⁸⁴

⁸⁴ Spaatz Box 122, USSTAF, "Report of Informal Conference at Pinetree July 6, 1942 with F/L BOGGIS, RAF, Photo Intelligence Liaison Officer with Eighth Bomber Command," 7 July 1942, 1-2.

As it turned out, Boggis and his bosses need not have worried. General Spaatz was entirely in favor of letting the British lead the photointerpretation effort at the CIU with Americans working alongside them in the various sections. This line of thinking matched the British view entirely, and the result was the formation of the Allied Central Interpretation Unit (ACIU), built on the foundation of the CIU, in 1943. As for American PRUs, Spaatz insisted that they were necessary but also put in place the necessary liaison officers to ensure they deconflicted their coverage with that flown by the British PRUs. This coordination took place at the Air Ministry's Assistant Chief Intelligence Officer for Photography—ADI(Ph)—until summer 1944 and then transitioned to the newly-formed Joint Photographic Reconnaissance Center (JPRC), an Anglo-American unit charged with managing the tasking, collection, processing, interpretation, and dissemination of aerial photographs and their associated reports.⁸⁵

As American photointerpreters arrived in Great Britain during 1942 and began working alongside their more experienced British counterparts in the ACIU, American senior airmen were already hard at work figuring out the most effective means for basing and employing the USAAF photoreconnaissance squadrons now beginning to arrive in Great Britain. Major General Ira C. Eaker, Commander of 8th Bomber Command, recommended to Lieutenant General Carl A. Spaatz, Commander, 8th Air Force, that all USAAF photoreconnaissance squadrons initially operate out of RAF Benson (where the British PRUs were stationed) for a short period to receive orientation training from the more experienced British pilots. He also recommended that all requests for photographic

⁸⁵ These developments receive more detailed attention in Chapter 8.

cover go to ADI(Ph), and that a USAAF liaison officer be stationed there to ensure maximum efficiency and minimum duplication of effort. Spaatz and the British agreed to both, and they were put into operation immediately.⁸⁶

At the same time, 8th Bomber Command staff officers recommended that USAAF reconnaissance squadrons be based at RAF Mount Farm to be as close as possible to the British PRUs at RAF Benson. The British had recommended this earlier for ease of operational coordination, more effective and rapid receipt of photographs and production of Immediate Interpretation Reports at RAF Pinetree, and more rapid courier service to British and American headquarters and intelligence organizations requiring copies of those reports. These actions, the British and Americans believed, would maximize the efficiency of the combined Anglo-American photoreconnaissance and photointerpretation processes. The American staff officers also recommended that USAAF reconnaissance units handle all missions, including post-strike BDA flights, requested by American headquarters, and that the American liaison officer at ADI(Ph) coordinate these sorties with British photoreconnaissance efforts. Although it soon became evident that the American units could not carry this burden by themselves, they did eventually become numerous and capable enough to do so. This vision for combined operations came to fruition with the arrival of the first American reconnaissance unit, the 13th Photographic Reconnaissance Squadron, at Mount Farm in February 1943.⁸⁷

Major James G. Hall, a World War I aviator from Texas, commanded the 13th Photographic Reconnaissance Squadron at the ripe old age of 47. He got his nickname,

⁸⁶ Spaatz Box 122, Memo, Eaker to Spaatz, 16 August 1942, 1-2.

⁸⁷ Spaatz Box 122, Memo, Colonel Leon W. Johnson, 8th Air Force G-3, to Captain Loren E. Ireland, Assistant G-3, 23 August 1942, 1-2.

“the Flying Broker,” because he mixed business and flying so capably. Hall brought to completion two vital business transactions upon his arrival in Great Britain, both of which Spaatz and Eaker had already approved in concept and were thus happy to support. Hall insisted, first of all, on coordinated operations with the British, resulting in his squadron’s posting to Mount Farm, next to the British PRUs at Benson. His second coup was to have his squadron—and all reconnaissance squadrons arriving after his—placed directly under the command of 8th Air Force. This resulted in a system of centralized control that maximized the effectiveness of the tasking and operations processes. Hall’s actions, which meshed perfectly with Spaatz’s and Eaker’s vision for Anglo-American reconnaissance operations, set the tone for all subsequent developments in the theater.⁸⁸

As the British and their American counterparts worked out the details regarding cooperation in the photoreconnaissance and photointerpretation efforts, American air intelligence officers also began working in other British intelligence organizations. A close cooperation developed in 1942 between the Economic Warfare Division at the American Embassy in London and MEW, both of which were concerned with economic intelligence and therefore the economic and military impacts of bombing on the German war effort. Mr. James Sommerville, the American liaison officer at MEW, ensured that American senior airmen received all available intelligence relating to the effects of Allied bombing. This proved a most useful conduit for the provision of MEW BDA reports to senior American airmen, who read them closely and often used them to frame their operational plans. General Spaatz in particular was deeply impressed with MEW reports on the German oil position and referred to them frequently in his arguments for an oil

⁸⁸ Patricia Fussell Keen, *Eyes of the Eighth*, 7-9; Babington Smith, *Evidence in Camera*, 155-156.

offensive in 1944. Eaker and Spaatz received MEW's Industrial Damage Reports, Weekly Armaments Reports (assessing the effects of Allied bombing on German armaments production), and reports on the Axis oil position (co-produced with the JIC's Technical Sub-Committee on Axis Oil). By summer 1942, Eaker was receiving two copies of every MEW intelligence report then in production, and the number of copies increased steadily in 1943 and 1944.⁸⁹

An MEW organizational chart given to Eaker and Spaatz explained the functions of each MEW section, including the Damage Assessment Section, which was "Responsible for assessing the effect on the enemy's economy of damage inflicted by air attack, combined operations, sabotage, accidents or other means for the use of Service Departments and other sections of Objectives Department in considering policy, and for the use of other Departments of M.E.W. in assessing current production, etc." This chart came with an agreement that intelligence officers on Spaatz's and Eaker's staffs could work directly with MEW analysts on BDA-related issues.⁹⁰

A similar record of close cooperation also developed quickly with RE8. Although this vital BDA producer was initially established to support RAF Bomber Command, it quickly became a primary provider of BDA reports to 8th Air Force and, in 1944, 15th Air Force. American airmen came to value RE8 BDA reports highly. They proved quite valuable in the Americans' efforts to determine the effects and effectiveness of their

⁸⁹ Spaatz Box 137, Memo and Report, James Sommerville (EWD liaison to MEW) to Colonel Robert Bacon (8AF G-2), "Functions of the Economic Warfare Division of the Embassy Services Available to the United States Armed Forces," 19 August 1942; Spaatz Box 137, Memo, Sommerville to Holford-Stevens at MEW, 6 July 1942, requesting copies of Industrial Damage Report, Weekly Armaments Report, and other MEW products of importance dealing with German war economy, for Colonel Hughes, HQ 8AF A-2; Spaatz Box 137, List, July 1942, of reports sent out each week from MEW to EWD and all other American customers, including HQ 8th Air Force.

⁹⁰ Spaatz Box 137, Organization Chart, MEW, 9 July 1942.

bombing; proper timing for re-attack of various targets; and the effectiveness of their bombs and fuses. Nor did the Americans ask their British comrades to do all this work alone. By August 1943, 15 Americans were working in RE8.⁹¹

The Americans also took their cue from the British on another key BDA and MEA producer: the Operational Research Section. By July 1942, the Americans had established their version, the Operations Analysis Section, within 8th Bomber Command. In August it produced its first report on the opening American bombing raid of the war, against the city of Rouen. In fact, Eaker had been focused on this problem since his arrival in Great Britain in March 1942.⁹²

American officers also began flooding into the Air Ministry's BDA and targeting offices in 1942. During his consultation with the American Joint Chiefs of Staff in December 1941, Air Vice Marshal Medhurst (Inglis's predecessor as Assistant Chief of Air Staff for Intelligence) agreed to provide USAAF headquarters and flying units with all air intelligence regarding the enemy, including target intelligence, target materials, and BDA. The first group of American officers arrived in April 1942. When Colonel Robert Bacon, 8th Air Force A-2, established his offices at London in May 1942, he assigned one of these officers, Major Kingman Douglass, to the Air Ministry as his liaison officer. Others followed in short order, taking jobs alongside their British hosts in A.I.3(c), which produced target materials, A.I.3(c)2, which produced "executive level" BDA, and A.I.3(U.S.A.), the Air Ministry office specifically responsible for ensuring the

⁹¹ Spaatz Box 186, RE8, "Brief Outline of Research and Experiments Department, Ministry of Home Security," n.d. but probably August or September 1943.

⁹² Eaker Box I:16, F10, Memo, Eaker to McClelland, 10 January 1943, 1. Eaker mentioned that, "As you know...I recommended last March that our Bomber Command duplicate an organization found at R.A.F. Bomber Command—the Operational Research Section."

efficient supply and distribution of all intelligence material and reports to USAAF headquarters and flying units—no small task. A.I.3(U.S.A.) conducted direct liaison with the CIU and ensured all required Interpretation Reports authored by K (Damage Assessment) Section, D (Industry) Section, and the other 15-plus sections producing them reached American customers with a minimum of delay. To speed this process, the Air Ministry assigned a production code to every British and American report produced in the European theater. These codes were keyed to specific distribution lists, each with anywhere from five to 300 recipients. As soon as a product went to press, couriers were ready to speed them to all the organizations on each distribution list. The Americans working at A.I.3(U.S.A.), along with their British colleagues, helped to ensure the proper American organizations were included on each distribution list. By January 1943, this process of liaison, coordination, and integration of air intelligence functions was beginning to assume the qualities of a well-oiled machine.⁹³

In the midst of giving the Americans all the air intelligence they needed, the British in turn received something of value: a growing sense that American bombing doctrine and tactics had the potential to do grievous harm to the German war effort. By September of 1942, senior officers at the Air Ministry were discussing in earnest what the American bombing capability presaged, and whether it was worthwhile or even wise to attempt to talk their allies into joining Bomber Command in a massive city-bombing

⁹³ Spaatz Box 290, "Liaison with Air Ministry," 8 September 1945, 1-3, located in USSTAF A-2, "History of Directorate of Intelligence, United States Strategic Air Forces in Europe, January 1944 – May 1945." To provide an idea of the degree to which the Americans became integrated into Air Ministry and other British air intelligence units, consider the experience of A.I.3c(1), the Air Ministry's Targeting Branch. The first USAAF officer joined seven RAF officers working there on 8 August 1942. As the scope and intensity of Allied bombing operations increased, the office expanded rapidly. By March 1944, there were 80 people assigned, including 27 USAAF officers, 25 RAF officers, 5 WAAF personnel, and 23 civilian administrative assistants. See Spaatz Box 297, "American Detachment at A.I.3c(1)," September 1944.

effort. Air Vice Marshal J. C. Slessor, recently appointed Assistant Chief of Air Staff (Policy), said of the Americans: "Their bombing has been extremely accurate as a rule. And I think we have seen enough of their performance in this and other theatres to be sure that their aircrews are fine material and will not be deterred by casualties."⁹⁴ Slessor closed with the thought that the Americans would convert their bomber force to night bombing only if casualties in their daylight raids proved prohibitive.

Nonetheless, a Chiefs of Staff paper published a month later pushed for an American contribution to the city-bombing campaign, but whether this combined effort was envisioned exclusively as a night effort, with the Americans assuming that role as well, was not made clear. Despite the misguided focus on city bombing, which the Chiefs of Staff imagined would lead to a 33 percent decline in German war production, there were several prescient observations. For instance, they envisioned an Anglo-American bomber force of between 4,000 and 6,000 bombers, dropping 90,000 tons of bombs per month on Germany by December 1944. They also foresaw an increasing diversion of Luftwaffe assets to the defense of the Reich, which they felt would "heavily handicap all German operations by land, sea and air in other theatres."⁹⁵ The Chiefs of Staff closed with a particularly important reminder: "It is concluded," they said,

that an Anglo-American bomber force of the size proposed could reduce the German economic and military strength to a point well below that at which an Anglo-American invasion of the Continent would become possible. This result might well be achieved before the combined force had built up to peak strength.⁹⁶

⁹⁴ AIR 8/711, Memo, "Note on U.S. Bomber Force," 26 September, 1942, 3.

⁹⁵ AIR 8/1014, COS (42) 379, "An Estimate of the Effects of the Anglo-American Bomber Offensive against Germany," 3 November 1942, 6.

⁹⁶ Ibid., 7.

Here again was the faith that heavy bombers would play a decisive role in the Allied victory. But there was also a clear reminder that they would do so primarily by reducing German economic and military strength to facilitate an invasion of the Continent. Also present in this statement, if implicitly, was the idea that heavy bombers would soon provide vital assistance to Allied ground forces on *all* the fighting fronts, whether in western Europe, Italy, or Russia. The Chiefs of Staff proved wise indeed, but a prolonged and costly battle for air supremacy over the Reich stood between them and their vision for the Allied bomber offensive. Yet through it all, Allied BDA capabilities improved, and by the time air supremacy was won, Anglo-American air intelligence organizations were poised to provide accurate BDA that told Allied senior airmen with a high degree of precision what their bombers were doing to the enemy's war effort.

7.7 Combined BDA Efforts at the end of 1942

We have seen how British air and economic intelligence organizations developed new BDA capabilities and methodologies to assess the accuracy, effects, and effectiveness of the British city-bombing campaigns that began in the spring of 1942. We have also seen, if only briefly as yet, how their efforts to develop quantitative and qualitative measures to gauge the effectiveness of Harris's offensives met with at least as much frustration as success. It remains to discuss briefly how the British and their American allies employed BDA reports in the closing months of 1942. This will give us some idea of the ways in which this Anglo-American interaction began to bear fruit even in the earliest days of their combined effort.

The first crystal clear indication that British "precision BDA" and American "precision bombing" would make a good match came with the first USAAF bombing

raid, to the Sotteville marshalling yard in Rouen, on 17 August 1942. A small force of 12 B-17s of the 97th Bomb Group, escorted by Spitfires, put their bombs squarely on the target. The CIU K Section BDA report for this raid summarized it as follows:

This sortie shows that, as a result of very accurate bombing, the main marshalling yards, two Transshipment Sheds between the Up and Down Sorting Sidings, and two factories, which most probably form part of the Repair Shops, have been severely damaged. Numerous wagons are seen to be damaged and derailed and there is little doubt that very considerable dislocation of working will have been caused on both the Up and Down Sorting Sidings.⁹⁷

The report then listed 13 individual buildings or other items damaged during the raid, providing additional details on the degree of damage caused by the 16 tons of bombs (45 500-lb. and 9 1,000-lb. weapons) employed. Photographs of excellent quality, taken by PRU1, made the photointerpreters' jobs easy. The damage was easy to interpret.

This BDA report, just one of many thousands to come, made clear several things of great significance for future Allied bombing campaigns. First, it confirmed that American daylight "precision" bombing could in fact be very accurate under the right weather conditions. British photointerpreters had seldom used the phrase "very accurate bombing" prior to this raid, and their excitement about having the opportunity to assess the effects of a precision raid against an individual high-value target is palpable in the report. They were clearly impressed. Second, it convinced a number of British and American BDA experts that if 12 B-17s could do this kind of harm to a major marshalling yard, several dozen could do grievous damage and perhaps even render the installation unusable for weeks or months. Third, it got several senior RAF officers, including Portal and his Deputy Director of Bombing Operations, Group Captain Sidney

⁹⁷ AIR 40/349, CIU, "Interpretation Report No.K.1373," 19 August 1942, 1.

Buften, thinking about what Bomber Command *night precision* sorties might accomplish against such targets.⁹⁸ Whether guided by Gee, Oboe, H2S Mark III, or some other radio or radar blind-bombing aid, or simply conducted using the Pathfinder Force and elite bomb groups, such raids, they reasoned, might be every bit as destructive as American raids, and perhaps even more so given that the British “heavies,” including the Stirling, Halifax, and Lancaster, carried 14,000 lbs. of bombs to the B-17’s 6,000-9,000 lbs. This combination of British BDA and American bombing was already changing the ways in which senior airmen thought about *how* they should bomb, about *what* they could and should bomb, and about what was possible once 4,000 or more American and British heavy bombers began going after high-value targets in the Reich and the occupied lands in both day and night precision attacks.

First, however, the British were committed to their city-bombing campaign, and they would continue it, despite steadily mounting losses, with the expectation that at some point it would undermine the German war economy and break the morale of German civilians and their Nazi overlords. Although British area bombing would do severe damage to German cities, it proved a failure in its stated aim—made repeatedly by Harris from 1942 to 1944—of knocking Germany out of the war. And it was BDA more than anything else that highlighted this failure. We turn now to this subject, and to the maturation of Allied BDA capabilities in 1943 and early 1944.

⁹⁸ Buften in particular was an advocate of precision bombing, whether by day or night. Webster and Frankland note, in Vol. I, 422, that “Air Marshal Harris, of course, regarded area bombing as an end ‘in itself,’ and if vigorously enough pursued, as a means of winning the war. Group Captain Buften thought it was only a preparatory phase through which Bomber Command would have to pass before it could perfect the technique of precise attack. The whole future tactical development of Bomber Command hung between these two extremes of opinion...” Buften was ultimately proved right, but not until 1944, after Harris’s methods had been tried and found wanting.

CHAPTER 8

BDA REACHES MATURITY: THE INTELLECTUAL INFRASTRUCTURE, JANUARY 1943- JANUARY 1944

8.1 City Bombing, Operational Frustrations, and the Limits of BDA

By January 1943 Bomber Command raids on German cities were increasing in frequency and intensity as more four-engine "heavies" and better navigational and bombing aids such as Oboe and Pathfinder Force came on line. For a brief period during 1943, anything seemed possible for the city-bombing effort, and the vast increase in destruction wrought by British bombers on German cities seemed to point to victory from the air. But it was not to be. The Germans proved exceptionally resourceful adversaries. They developed superb repair and reconstruction capabilities, began dispersing large numbers of their factories, and put servile and slave laborers to work in them. Nonetheless, British bombing was having an effect on German war production if only because it forced the Germans to begin large-scale dispersal efforts. This impeded efficiency and reduced the quality of finished weapons because component parts had to be produced in separate locations without adequate quality control. As we will see, this proved detrimental to the quality of weapons and therefore of German combat power. The dispersal process itself also created a serious risk unforeseen by the Germans: It forced them to relocate production to small plants all over Germany, whose output had to

be shipped to central locations for assembly. This vulnerability proved disastrous once concerted Allied bombing of the Reich's railroads and canals began in late 1944.

In the meantime, Harris pressed the city-bombing campaign harder than ever and advocated ceaselessly its potential to win the war. Yet the Americans had begun to arrive in force by this time, and they had a very different idea about how best to use heavy bombers. Their advocacy of high-altitude, daylight, precision bombardment, and the good results they obtained in early raids, forced British civilian and military leaders to pay heed to their ally's preferred doctrine. In September 1942, Air Vice Marshal Slessor, the Assistant Chief of Staff for Policy, reminded Portal that it was not a good time to press the Americans to join in the city-bombing effort, particularly with Congressional elections coming up in the U.S. Any such effort might, he feared, result in an anti-British backlash. "I suggest," Slessor said, "that it might have unfortunate results if we cast official doubts on the day bombing policy just now when the new Air War Plan [Air War Plans Division Plan 42, or AWPDP 42] is before the U.S. Chiefs of Staff." Then the deeper agenda emerged: "True the B.17 and B.24 are not ideal but they could be made quite useful night bombers. I would prefer to say nothing about this at present."¹

The British need not have concerned themselves: The Americans were not interested in night bombing. In fact, when Major General Ira C. Eaker, the 8th Air Force Commander, made his famous pitch for a Combined Bomber Offensive (CBO) to Churchill and Roosevelt at the Casablanca Conference in January 1943; they approved, and that ended the debate. To be sure, there would be more discussions in late 1943, after heavy losses at Schweinfurt and Regensburg threatened to undermine the American day

¹ AIR 8/711, Minute, Slessor to Portal, 26 September 1942.

bombing effort. Even then, however, American airmen stayed true to the doctrine they had developed during the interwar period, and the arrival of drop tanks for P-47 and P-51 fighters brought their effort back from the brink.

The Combined Chiefs of Staff (CCS) directive following the Casablanca Conference allowed Bomber Command and 8th Air Force to do what they wanted but nonetheless tried to bring their efforts together in a meaningful way. The CCS told Harris and Eaker:

Your primary objective will be the progressive destruction and dislocation of the German military, industrial and economic system, and the undermining of the morale of the German people to a point where their capacity for armed resistance is fatally weakened.²

From there, they directed the bombing effort to focus on five objectives: German submarine construction, the German aircraft industry, transportation targets, oil plants, and other targets in the German war industry. Further, they told Harris and Eaker to attack German submarine bases on the Bay of Biscay, and to go after Berlin with enough frequency to affect German morale in the Reich's capital city. The CCS emphasized that

You should take every opportunity to attack Germany by day, to destroy objectives that are unsuitable for night attack, to sustain continuous pressure on German morale, to impose heavy losses on the German day fighter force and to contain German fighter strength away from the Russian and Mediterranean theatres of war.³

Equally important was their reminder about the role of airpower in a combined-arms effort: "When the Allied Armies re-enter the Continent, you will afford them all the

² CCS 166/1/D, "Combined Chiefs of Staff: The Bomber Offensive from the United Kingdom," 21 January 1943, 1.

³ Ibid., 2. Note the continuing emphasis on attacking German U-boat bases even though BDA reports had made clear many times the futility of such attacks. Arguments about the importance of these attacks as a tonic for Allied morale aside, they were entirely ineffective and the most tragic waste of bombing effort during the entire course of the war. The most astonishing thing is that the attacks continued on a large scale even after the Allies had won the Battle of the Atlantic in the spring of 1943. This was one of the few cases in which Allied political leaders and senior airmen ignored BDA reports altogether, which was an inexcusable failure on their part.

possible support in the manner most effective.”⁴ These two points were particularly important because they made clear the Chiefs’ recognition that heavy bombers would play a decisive role in the Allied war effort but could not win the war on their own. Harris’s preferences notwithstanding, most Allied civilian and military leaders viewed heavy bombers in their proper combined-arms context.

Harris nonetheless took full advantage of the CCS directive to continue his city-bombing effort at full tilt. His well-known disdain for attacks on specific target sets, which he referred to as “panacea targets,” all but assured that the Americans would do most of the work when it came to attacking the high-priority target sets put forth in the Chiefs’ directive and destroying the Luftwaffe. The British did engage targets within the high-priority target sets, but for the most part only incidentally as they went after German cities. If such a target happened to be in a city attacked by Bomber Command, and bombs happened to hit it, Harris’s aircrews could then be said to have contributed to the objectives set forth in the CCS directive. Harris, in any case, turned the full fury of an increasingly capable Bomber Command against Germany’s cities. Bomber Command was now equipped almost entirely with four-engine “heavies” carrying up to 14,000 lbs. of bombs each, bombing and navigation aids such as Oboe and the H2S Mark III radar, high-explosive “Blockbuster” and incendiary munitions, an improving Pathfinder Force equipped with an excellent target-marking bomb, and the tactical acumen necessary to put a thousand-bomber attack over a German city in 20-30 minutes. This was a formidable force bearing no resemblance to the weak instrument of 1939-41.⁵

⁴ Ibid.

⁵ A review of these improvements is in Middlebrook and Everitt, *Bomber Command War Diaries*, 334-338.

By March 1943, Harris felt ready to go after the industrial cities of the Ruhr, which came under heavy attack from 5 March to 24 July 1943. These attacks, which benefited from Oboe, seemed to lend further credence to Harris's view that bombing alone might win the war. Oboe, the successor to Gee, was similar in that it kept British bombers on course by allowing them to fly along a radio beam, and, once over the target, to drop their weapons within 300 yards of the aimpoint. Only a few aircraft per raid could do this given the limited number of ground stations in Great Britain. There were only three, each of which could control a maximum of six aircraft per hour. However, with these bombers placed at appropriate locations in the bomber stream, they in effect guided all the bombers to their proper release points. Another great advantage was the ability to mark targets accurately in no-moon and bad-weather periods, which were no longer an obstacle to bombing in western Germany. Oboe's major shortcoming was its line-of-sight restriction, which was not a problem for attacks on the Ruhr but a serious one for attacks on targets in central and eastern Germany, all of which were beyond its range.⁶ Nonetheless, Oboe signaled a major increase in the accuracy, effects, and effectiveness of British bombing. In fact, during the 10 months from March through December 1943, Bomber Command raids caused 10 times the level of destruction as all the raids flown in the preceding 45 months of the war.⁷

The opening raid of the campaign, against Essen on 5-6 March, confirmed the value of Oboe. Five Oboe-equipped Mosquitoes of the Pathfinder Force marked Essen's city

⁶ Middlebrook and Everitt, *Bomber Command War Diaries*, 334-335, 362-364.

⁷ AIR 14/1210, Bomber Command, "Review of Work of Intelligence 1 Section (Target Intelligence & Damage Assessment) 1939-1945," 18 August 1945, 17.

center perfectly through heavy haze. Then, 442 bombers dropped their bombs directly on target. Post-strike reconnaissance photos showed that 160 acres of the city center had been destroyed and that 53 separate buildings within the huge Krupps factory complex had been destroyed or damaged. German reports later confirmed British estimates that over 3,000 houses were destroyed and 2,166 severely damaged. Nearly 500 people were killed. A follow-up raid on 12-13 March caused even greater damage to Krupps and destroyed another 500 houses. A third raid on 3-4 April caused further damage. An RE8 assessment of the effects of these raids on the Krupps works noted that 114 tons of bombs fell on the Krupps complex, a total of 75 tons per square mile. Nearly 25 percent of buildings in the complex were damaged, with delays of up to 32 weeks for several industrial processes as repairs progressed. Analysts at RE8 estimated that Krupps lost three months' production. They also observed that repairs were much slower than anticipated, which was puzzling given the excellence of German repair work. What the analysts missed was the dispersal of work away from the factory and the German penchant for continuing work in buildings with damaged upper stories but intact ground floors and basements. Nonetheless, the RE8 report was correct in asserting that Krupps had suffered severe damage.⁸

Because Krupps was a high-value facility, RE8 personnel also produced a report on reconstruction, noting that perhaps 40 percent of the factory complex's productive output had been destroyed until at least December 1944. This damage resulted from the first three raids and another three flown in May and July. The total weight of attack on Essen

⁸ HO 191/116, RE8, "The Effects of the Essen Raids on Krupps: March 5/6, March 12/13, April 3/4 1943," May 1943, 1-3.

was nearly 7,000 tons, almost evenly divided between high-explosive and incendiary bombs. Analysts also assessed that neither abandonment nor full repair of the complex was the Germans' aim, and in this they proved correct, although they had not yet ascertained why: the dispersal of several operations to other locations. This kind of detailed BDA for a high-value industrial complex was precisely the kind of work photointerpreters and intelligence analysts performed with increasing frequency in 1943, honing their skills for later campaigns, in which "precision" attacks became the norm.⁹

An MEW damage assessment, based largely on CIU K Section's Immediate Interpretation Report No. K.1497, made the same error in its assessment of the effects and effectiveness of the 5-6 and 12-13 March raids on the German war effort. Although assessing correctly that the raid destroyed 75 percent of all the buildings in the 450-acre central district of Essen and caused severe damage to Krupps, MEW analysts erred in assessing that the Germans would have great difficulty rebuilding damaged industrial plant and resettling "de-housed" civilians. The Germans did both very effectively, in Essen and throughout the Reich.¹⁰

Frequent raids on cities throughout the Ruhr and further afield continued with increasing ferocity from March through September. Essen, Dortmund, Düsseldorf, Wuppertal, Bochum, Krefeld, and Mülheim were largely burnt out. Outside the Ruhr, Cologne, Aachen, and Hamburg suffered severe damage. The latter, attacked on 27-28 July, was engulfed in the largest firestorm yet caused by British bombing. One of the

⁹ HO 191/117, RE8, "Damage Assessment and Reconstruction Report: Damage and Reconstruction at Krupps, Essen: within the period 5th March 1943 to 16th September 1943," January 1944, 1-3.

¹⁰ AIR 14/1229, MEW, "Preliminary report of damage to Essen as shown by C.I.U. Immediate Report No. K.1497," March 1943, 1-2; AIR 14/1229, MEW, "Attacks on Essen," March 1943, 1-2.

most significant things about this raid, aside from its destructiveness, was the accurate Pathfinder Force marking and main-force bombing of a target well *outside* the range of Oboe. Another was the use of chaff, which the British called Window. Comprised of bundles containing thousands of strands of aluminum, Window blinded German radar, which as yet lacked moving target indicators. British bombers were thus able to attack German cities with very little resistance until moving target indicators became available to the Germans in August 1943. This period also encompassed the opening attacks in Harris's grandest scheme: the Battle of Berlin, which he expected to result in German capitulation but instead nearly destroyed Bomber Command. In fact, as the Germans adjusted to British night tactics and devised countermeasures, the British loss rate climbed to 7 percent or more per raid.¹¹

By the time the Battle of the Ruhr ended in July-August and the Battle of Berlin began, Bomber Command had done grievous damage to many German cities, especially those in the Ruhr. An RE8 BDA report assessed the effects of 15 raids on nine cities between 4 July and 30 September 1943. The report concluded that about 9.5 percent of non-industrial and 5 percent of industrial buildings in these cities were destroyed or seriously damaged. In total, the nine towns lost about three weeks' production and approximately 4.1 million man-months of labor, which equaled 25 days for every worker in each of those towns. This focus on man-months and man-hours of labor lost was joined by an equally heavy emphasis on dwelling units and factories destroyed or damaged, the former to gauge the morale effects of the raid as well as the costs of

¹¹ For an excellent synopsis of these various raids, see Middlebrook and Everitt, *Bomber Command War Diaries*, 362-365 and 417-419.

resettling the homeless, and the latter to gauge the effects on Germany's war economy. These figures were fairly precise but posed more questions than they answered.¹²

The figures came directly from "Raid Assessment Data Sheets" produced for every major raid on a German town, which listed its population, number of industrial workers, and dwelling units. They then provided calculations of damage to industrial and commercial buildings and housing units, estimated the total casualties, and assessed industrial loss caused by the raid. The last calculation was the most important and included production lost as a result of damage and the repair time required to bring each plant back on line, absenteeism due to the workers' loss of housing and subsequent resettlement, and the loss of man-hours due to diversion of labor from production to relief and repair efforts. The end result of this assessment was total production loss in millions of man-hours and by individual worker. Thus, in the case of a 13-14 July raid on Aachen, RE8 analysts, who reviewed all PRU post-strike photo and CIU K Section BDA reports, placed the industrial loss at 34 million man-hours or 128 days' lost labor for every worker in the city. Loss of man-hours in fact became the *sine qua non* of RE8 damage assessments in 1943.¹³

The problems with these figures, however, were serious, for reasons previously discussed, most prominently the extensive use of slave laborers and the dispersal of factories. The problem lay in the fact that relocation represented a loss of productive labor and time, *but only once*, while the RE8 analyses assumed that lost man-years accumulated *every time* a bombing raid destroyed houses and factories. The failure to

¹² HO 191/116, RE8, "The effects of British air attacks in force on German targets during the period 4th July to 30th September, 1943," 19 October 1943, 1-2.

¹³ AIR 14/1228, RE8, "Raid Assessment Data Sheets," various raids and dates.

detect large-scale movements of skilled German workers and their families to the new dispersed factories, and the importation of expendable servile and slave labor into the cities to carry on repair work and resume production at the remaining plants, were among the most costly oversights in the Allied BDA effort.

Another problem with the figures was the difficulty of squaring them with an obvious increase in German productivity and output of weapons throughout 1943. This problem grew out of MEW's flawed assessment that the German war economy had been fully mobilized since 1940, when in fact it would not be until early 1944. It also stemmed from a failure at Bomber Command to engage in an intellectually honest BDA effort. Bomber Command reports were concerned with lost man-hours of labor, but also placed heavy emphasis on the destruction of German cities and buildings. One such study, produced in November 1943, noted that the total area destroyed in raids on the 38 largest German cities was 84,848 acres (32.5 square miles) or 25.5 percent of the built-up areas in these cities. Of this total, 29 square miles were destroyed during 1943, with the rest destroyed in 1941-42.¹⁴ Aside from the fact that such figures said nothing about the German will and ability to continue fighting, they became, at times, an end in themselves, as if burning out Germany's cities would translate automatically into capitulation.

Harris's patience grew thin by late 1943, but no capitulation was forthcoming, so he loosed Bomber Command against Berlin. He felt that the capital of the Reich, with its three million inhabitants, large marshalling yards, and 196 major factories, held the key to compelling the Nazi leadership to sue for peace. With the severe damage already done to cities in the Ruhr and elsewhere, Harris was sure an all-out effort against Berlin would

¹⁴ AIR 14/1229, Bomber Command, "Statistics of R.A.F. Damage to Enemy Towns," 10 November 1943.

do the trick.¹⁵ Appealing for American support, which was not forthcoming, Harris said “We can wreck Berlin from end to end if the U.S.A.A.F. will come in on it. It will cost between 400-500 aircraft. It will cost Germany the war.”¹⁶ A month later, as his bombers and their crews sustained unprecedented losses and German air defenses forced his bombers to operational altitudes above those at which his Stirlings could fly, he made the outlandish claim that his Lancaster bombers *by themselves* could inflict “a state of devastation in which surrender is inevitable” by 1 April 1944.¹⁷ Unfortunately, by April Fool’s Day 1944, the joke was on Harris, despite the sacrifice and gallantry of the Bomber Command aircrews involved in this resounding defeat.¹⁸

As the Battle of Berlin raged, Bomber Command’s Chief Intelligence Officer released a key BDA report, compiled from earlier ACIU, RE8, and MEW reports, purporting to demonstrate the decisive results of Bomber Command’s city attacks from 1 March to 31 December 1943. What it did, instead, was highlight how *little* Bomber Command had done that was of *decisive* importance. In fact, the report foundered on the same shoals that had sunk earlier BDA efforts: the fixation on man-hours of labor lost

¹⁵ AIR 34/199, CIU, “Industry Interpretation Report No. D.32., Berlin,” 14 November 1941. This 22-page document emphasized the great importance of Berlin to the German war effort by noting the hundreds of industrial concerns in and around the city. Given Harris’s effort to undermine German war production and morale by destroying her cities, this report can only have convinced him that destroying Berlin would prove decisive, forcing a German surrender.

¹⁶ Minute, Harris to Churchill, 3 November 1943, quoted in Webster and Frankland, *Strategic Air Offensive*, Vol. II, 48.

¹⁷ AIR 8/425, Memo, Harris to Air Ministry, 7 December 1943.

¹⁸ Airpower historians are in general agreement that the Battle of Berlin was a decisive British defeat. Far from driving Germany to the negotiating table, it nearly broke Bomber Command. Although the battle, which began in August 1943 and ended with the disastrous 30 March 1944 Nuremberg raid, focused on Berlin, it involved attacks on several cities, including Leipzig and Nuremberg. The campaign received scant attention in Harris’s *Despatch on War Operations* (London: Frank Cass, 1945) and his *Bomber Offensive* (New York: The MacMillan Company, 1947), and the raid on Nuremberg was entirely absent. The fact that it was the costliest Bomber Command attack of the war, claiming 95 of the 795 aircraft involved—11.9 percent of the total force—should have merited at least a mention. See Middlebrook and Everitt, *The Bomber Command War Diaries*, 487-488.

and the number of structures destroyed, an inability to define what comprised “decisive” results, and a total failure to translate “morale effect” into a meaningful or quantifiable measure. The report began with an assessment that British bombing had cost Germany one million man-years in lost labor. “The loss inflicted on the enemy,” it said,

represents the total loss of nearly a complete month’s work by every single factory worker in the whole of greater Germany. This has not fallen indiscriminately but has affected most the essential war workers, while those who have escaped direct effects of air attacks are predominantly those who contribute least to the war effort.¹⁹

The report was wrong on both counts, first because many of Germany’s skilled workers were already working at dispersed plants, where bombing had little or no effect on them, and second because bombing did the greatest harm to those who contributed the *least* to the German war effort, were seen as the most *expendable*, or both. Those in the first category included old people, children, and, to a lesser degree, women, while those in the latter category included foreign servile and slave laborers. Equally important was an RE8 reminder that key industries, including aircraft factories and ball-bearing plants (both of which were now at the top of the Allies’ target priority list) tended to be located on the outskirts of cities and thus less likely to be damaged by Bomber Command raids. Only precision-instrument and chemical factories, which were often in old buildings near the center of German cities, tended to be hit by city raids.²⁰

An even more telling sign of Bomber Command’s failure to knock Germany out of the war single-handedly, as Harris insisted it could, was the cumulative damage that city-

¹⁹ AIR 14/1228, Bomber Command, “Progress of R.A.F. Offensive against German Industry, 1st March 1943 – 31st December 1943,” 19 February 1944, 1.

²⁰ AIR 14/1228, Memo, RE8 to Squadron Leader Fawcett, HQ Bomber Command, 6 March 1944.

bombing raids had thus far inflicted on key German industries. Serious damage, according to the report, had been done to 0.4 percent of liquid fuel production facilities (which British intelligence agencies held to be the both the most important industry and the one most vulnerable to concerted attack), 0.2 percent of single-engine fighter aircraft factories (the highest-priority Combined Bomber Offensive [CBO] target by this time), 1.1 percent of other aircraft plants (including those producing bombers, another high-priority CBO target), 0.5 percent of aero-engine plants (yet another high-priority CBO target), and 0.0 percent of Germany's ball-bearing factories (ditto). The results for synthetic rubber were equally dismal at 0.5% of total capacity. The only target categories where serious damage was done included engineering and armaments (32.1 percent), chemicals and explosives (10 percent), textiles (13.6 percent), and food (11.8 percent).

The damage to engineering and armaments plants, and to chemical plants, both of which were vital industries, did indeed appear serious. However, the measure of merit Bomber Command used to describe "serious damage" was not the percentage loss of production for each industry, but rather the percentage of *factory floor space*, measured in square feet, which had been seriously damaged by bombing raids. There were two huge problems with this. First, percentage of floor space damaged *did not* equal percentage of lost production. In many cases, production continued even in damaged factories, and of course the Germans also dispersed increasing numbers of their industrial operations, leaving fewer high-value items and processes to be damaged by Bomber Command city raids. Second, the British had missed altogether the "slack" in German war production prior to 1941, which allowed it to expand rapidly after that. Consequently, they underestimated both the production levels and the floor space

associated with each industry. Bomber Command's figures, already inaccurate and misleading due to the use of damaged floor space as their measure of merit, were therefore doubly inflated because they were based on damage as a percentage of floor space at all *known* facilities within a given industry. Between the new construction and the dispersal that had begun in earnest by summer 1943, productive capacity was in most cases greater than the British realized. Bomber Command's damage figures, had they been adjusted for these realities, would have been even smaller.

Given these serious problems with Bomber Command's figures, it becomes clear that only the damage done to the engineering, armaments, and chemicals industries was significant. As for damage to textiles and food production, neither one caused the Germans much discomfort. They had long been expropriating both from the occupied lands and in fact would not experience any textile shortages until early 1945. And although German civilians were running short on food by then as well, there is little evidence that German armies in the field ever did.

Viewed in this light, BDA reports for Bomber Command's city raids might best be termed technically excellent but analytically flawed. The flaw was due to the influence of Arthur Harris, who was determined to demonstrate that his city-bombing effort was paying dividends. Any doubts about the influence Harris had over his command's BDA reports disappear as we read his Intelligence Directorate's statement on the effects and effectiveness of Bomber Command's city raids from 6 March 1943 to 6 March 1944:

So, as this period drew to a close it became apparent that Bomber Command had done its job in preparing the way for the Armies' return to the Continent; the back of the enemy's war machine had been broken and the problem now was how the Strategic Bomber Forces were, over the next few months, to keep the shattered industries of the Reich from recovering too fast and to stop the movement of supplies

and equipment from Germany to France. It had been a year of success on a scale never hitherto imagined, and there was not a home in Germany that was not reaping the harvest which it had helped to sow.²¹

The only problem with this statement, of course, was that the back of the enemy's war machine had *not* been broken by Bomber Command raids, as its own BDA reports made clear, nor had the Luftwaffe's back been thus broken. The former task was accomplished much later with the oil and transportation campaigns, and the latter by USAAF day raids on fighter, aero-engine, and ball-bearing factories, which forced the Luftwaffe into a huge battle of attrition it could not win.

That leaves one other BDA-related issue: morale, the secondary objective in Bomber Command's city campaigns. Predictably, even the brightest BDA experts failed to come up with an equation to measure what was, in effect, not measurable in any but the most general terms. A steady stream of agent reports from Germany indicated that German civilian morale deteriorated as the weight of Bomber Command's attacks increased, but they also made clear the utter lack of interest in surrender on the part of the Nazi leadership. Although it took some time to recognize the futility of trying to defeat Germany by breaking her people's morale, the Combined Chiefs of Staff directive of September 1944 closed the issue decisively. It was modeled on the original guidance provided in the January 1943 directive, stating that "The overall mission of the Strategic Air Forces is the progressive destruction and dislocation of the German military, industrial and economic systems and the direct support of land and naval forces."²² It was the last part of the statement that differed radically from the original: Morale was no

²¹ AIR 14/1210, Bomber Command, "Review of Work of Intelligence 1 Section (Target Intelligence & Damage Assessment) 1939-1945," 18 August 1945, 25-26.

²² Spaatz Box 186, Cable, Bombing Directive, Portal and Arnold to Bottomley and Spaatz, 15 September 1944.

longer even mentioned. And so the "morale effect," first introduced by Trenchard and echoed by virtually every airman since, finally died a quiet and long-overdue death.

Despite Bomber Command's inability to defeat Germany on its own and the unconvincing BDA reports it produced, Bomber Command's efforts did pay dividends in conjunction with USAAF raids. An RE8 BDA report noted that from March through December 1943, bombing had done serious damage to 190 million feet (seven square miles) of industrial and 590 million square feet (21 square miles) of non-industrial property. This damage included 4.5 percent of estimated total factory building space in Germany. British bombs destroyed 1.4 million dwellings, forcing the resettlement of over 4.5 million people. This represented 6 percent of total dwelling units in Germany and 25 percent of in towns attacked during this nine-month period. RE8 estimated that bombing caused a 9 percent aggregate loss in war production with the heaviest losses to machine tools (59 percent), single engine fighter aircraft (17 percent), ball-bearings (20 percent), and synthetic rubber (10 percent), with the last three the result of *USAAF* precision attacks, *not* Bomber Command area raids. Although the same problems are evident here as were present in the Bomber Command assessment discussed earlier, the portion dealing with USAAF raids was much more decisive in its assessment of damage. Clearly, RE8 analysts preferred writing BDA reports dealing with damage to individual installations as opposed to wrestling constantly with the man-hours-lost and square-footage-destroyed measures of merit, neither of which provided an accurate or useful measure of damage to the German war effort.²³

²³ AFHRA 512.57, RE8, "The Economic Effects of Attacks in Force on German Targets, March-December 1943," 15 February 1944, 1.

Even the Bomber Command raids, however, clearly caused a large measure of disruption, dislocation, and dispersal of factories and human beings. When considering these effects it is important to keep in mind one of the key arguments made at the beginning of this work: that Allied bombing was the creator of friction *par excellence* in the German war economy. This held true to at least a moderate degree in the city attacks. They were not decisive in their own right—in fact, they were not even close to being so—but they did create friction, whether in halting production in various factories for short periods of time or forcing the dispersal of German war industry, which was certainly the greatest, if nonetheless unintended, consequence for Germany.²⁴ The dispersal process proved beneficial to German war production in the short term but disastrous once Allied bombers began attacking the German transportation network in late 1944. As German railroads and inland waterways fell prey to bomber attacks, it became increasingly difficult to move the thousands of component parts for weapons, now produced in hundreds of dispersed locations, to their central assembly points.

Perhaps the most important fact about Bomber Command's BDA—that it was technically excellent but analytically flawed—stems from the fact that it rested on very detailed ACIU, RE8, and MEW reports, which provided a veneer of sophistication but could not conceal the deeper failings in Bomber Command's city-bombing effort. An RE8 senior analyst brought out this problem when he discussed the difficulty he and his colleagues were having in their efforts, at Bomber Command's request, to determine the point at which a city became a "net liability" to the German war effort. He said "The

²⁴ Surprisingly, the United States Strategic Bombing Survey overlooked this important effect of Bomber Command attacks. It was one of the few oversights in an otherwise exhaustive study of bombing's effects and effectiveness.

concept is a tricky one and I am afraid that I still have nothing very satisfactory to suggest.”²⁵ Their best guess was that if *total industrial loss + loss of time by other workers + consumption of goods and services by inhabitants of the town > the potential industrial and non-industrial output of a city*, then the city had become a net liability. However, the RE8 analysts must have recognized that there was a serious problem with this methodology. To begin with, cities were already net liabilities in terms of the food and other consumer services they required, so it might, ironically, have been a *lesser* burden on the German war economy once the thousands of homes destroyed by bombing no longer demanded natural gas or coal for heating, electricity to provide light, or consumer goods to keep residents happy. Food was the only constant, and the German authorities proved adept at looting the occupied lands to keep German civilians fed. Similarly, alternate lodging arrangements proved less costly than the British estimated. The loss of production time at factories was a problem, as was the loss of worker man-hours, but these were generally one-time benefits of city bombing that ceased to accrue to the Allies’ advantage once factories were dispersed, which was already occurring even as British bombing intensified in 1943.

By 1944, there were signs of discontent at RE8 about the requirement to provide imprecise and questionable measures of merit for the city-bombing effort. In a memo to Air Commodore N. S. Paynter, Bomber Command’s Chief Intelligence Officer, the former head of RE8 said

I get the impression that the main difficulty between Bomber Command and R.E.8 arises from the differences in the point of view of the enthusiast and that of the

²⁵ AIR 14/1228, Memo, RE8 Division Director to SL F. Fawcett, Bomber Command Intelligence, 27 March 1944, 1-2.

investigator who is endeavouring to prepare an impartial statement of the facts...R.E.8. now seem to be realizing the limitations of their method and the introductory paragraphs of their [latest] paper are therefore full of qualifications...The real difficulty in all these papers is that there is no satisfactory statistical measure of the amount of damage done. Any paper which attempts to assess the imponderable factors [he included morale here] must therefore appear to the statistically minded to be lacking in precision.²⁶

Here, then, was the crux of the problem. RE8 analysts, "statistically minded" and trained to make the most detailed and specific assessments possible, saw their efforts founder on the shoals of Bomber Command's insistence that the figures be made to look as impressive as possible even if they were necessarily vague and unconvincing. Small wonder that RE8 analysts—and their ACIU counterparts—preferred writing BDA reports for American raids. After all, they could make very specific, accurate, and convincing judgments about the effects of USAAF bombing.

This spat between RE8 and Bomber Command was only the latest round in a long-running series of disagreements between Air Marshal Harris, who felt the air intelligence support he received from the Air Ministry, ACIU, RE8, and MEW was inadequate, and the various air intelligence agencies, who felt Harris was asking them to do the impossible; in other words, to make precise assessments about the effects and effectiveness of city-bombing on the German war economy and German morale, neither of which lent themselves to precise estimates. Harris, for instance, was constantly after Portal and his Assistant Chief of Air Staff (Intelligence), Air Vice Marshal Fred Inglis, to provide better BDA reports as early as March 1943.²⁷ Inglis responded with a note to Portal in which he quite properly emphasized that

²⁶ AIR 14/1228, Memo, Former RE8 chief to AC Paynter, CIOBC, 3 March 1944, 1-3.

²⁷ AIR 8/833, Memo, Harris to Portal, 30 March 1943.

Hitherto the directive to Bomber Command has been so broad that it is not always possible to recognize in each attack the exact aim within the directive. Morale of workers appears to have been the main aim in the last 12 months. It would I think, therefore, be profitless and misleading to review over the last 12 months the damage suffered by specific industries.²⁸

This was a particularly ironic note because it made clear the confusion within the Air Ministry, and no doubt within Bomber Command itself, about the proper level of emphasis on morale as an objective. Inglis clearly read the bombing directive then in force as placing morale at the top of the list of Bomber Command's objectives, but Harris himself never made it his top priority.

Therefore, having placed the basic problem—lack of clear guidance—where it belonged, that is, with Portal and Harris, Inglis proceeded to enumerate the problems with assessing the results of Harris's city-bombing effort. First was his reminder that the ACIU and RE8 could record the number of hits on a factory building but not the precise effects these hits had on output. Nor did this analysis provide an accurate estimate of the rate of repair. Even more important was his recognition that British intelligence agencies did not know what kinds of effects bombing was having on German war production, since the *Germans'* target figures for production of various weapon systems were unknown. This observation also alluded to the issue, addressed earlier, of the amount of "slack" in the German war economy as late as summer 1943. Inglis closed by noting that any BDA report attempting to portray such figures would be "so unsatisfactory as to make its publication outside the Service profitless and dangerous."²⁹

²⁸ AIR 8/833, Minute, Inglis to Portal, 8 April 1943.

²⁹ Ibid.

Although Harris continued to harangue Portal for weeks after this initial exchange, asking for a major expansion of the Air Ministry Intelligence Directorate specifically to provide Bomber Command with BDA reports, Portal supported his intelligence chief, the ACIU, RE8, and MEW, noting that they were doing the best they could to provide precise estimates for bomb damage to German industries and morale. He further noted that MEW was dedicated to doing everything possible to deliver useful damage assessments for Bomber Command, noting the advantages, from a credibility standpoint, of having a civilian intelligence agency produce BDA reports on the effects of Bomber Command raids on Germany's war economy.³⁰

Although Harris's desire for comprehensive and flawless intelligence was understandable (this is what *every* operational commander wants), his refusal to recognize the clear limitations inherent in BDA reports for the city-bombing effort can only be viewed as part of the larger problem with Harris's fixation on winning the war with bombing alone. He wanted reports showing decisive effects when in reality there were only modest ones. Harris sought damage assessments portraying Bomber Command's city-attacks as the key to Allied victory, when in fact it became increasingly clear during 1943 that they *were not*, in fact *could not be*, decisive on their own. The most unfortunate thing, for Harris and the BDA producers, was his insistence on an all-or-nothing approach to BDA. Harris's refusal to entertain anything in the middle ground, including the possibility that by forcing a rapid dispersal of German industry, his aircrews were doing something of significant value, both in the disruption they caused German war production and in the many inefficiencies related to the dispersal effort, was

³⁰ AIR 8/833, Memo, Portal to Harris, 27 April 1943; AIR 8/833, Memo, Harris to Portal, 29 April 1943.

particularly unfortunate. The BDA reports Harris received from RE8 and MEW did make clear that bombing was having an appreciable effect on the German war effort, but this was not enough for Harris, and so he labeled the BDA effort a failure rather than recognizing its merits.

8.2 A Combined Capability: American Arrivals and Improved BDA

The arrival of Americans in the European theater accelerated rapidly in 1943. However, the differences between British and American bombing doctrine created several problems as the British sought to meet American BDA requirements while training and integrating Americans at the Air Ministry, ACIU, RE8, and MEW. The first effort to address these issues occurred at a meeting called by the Air Ministry in March 1943 to discuss requirements for producing damage assessments that satisfied both parties' requirements. Fortunately, Group Captain Sidney Bufton, the Air Ministry's Deputy Director of Bombing Operations and a firm believer in both American *and* British precision bombardment, chaired the meeting. His emphasis on the production of damage assessments for "precision" as well as area attacks helped to ensure a mature BDA capability would be in place for assessing the effects of the transportation and oil offensives in 1944-45. Intelligence officers from all the BDA-producing organizations attended. Bufton began by saying the commands and agencies represented at the meeting produced a variety of reports on bomb damage, but none produced anything assessing the aggregate effects of area and precision bombing or the ways in which they were either complementary or duplicative. Bufton was concerned that no interagency machinery existed to assess the effects of bombing on various target sets and the individual targets

within them. "If we made a series of concentrated and successful raids," he asked, "what would be the true effect upon the German war effort?"³¹

There was general agreement on the need for the ACIU and RE8 to produce damage assessments for area and precision raids, and for MEW to assess the aggregate damage done by both to the German war effort. In a veiled attack on his own command's bombing doctrine, Group Captain Paynter, Bomber Command's Chief Intelligence Officer, argued that "we have got to look ahead to the time when we will be more accurate in our bombing; when we have bombed out the heart of our present targets we should have to look elsewhere."³² Clearly, Paynter saw the air war extending beyond Harris's city-bombing efforts and involving British *precision* attacks alongside those of the Americans. He and Bufton were kindred spirits in this respect, and their vision became reality in 1944-45. Equally important for the development of BDA capabilities was a statement by Mr. Lawrence, the MEW representative, that if bombers went after a specific target set such as oil or transportation, MEW had the sources at hand to assess the aggregate effects of those attacks. Mr. Lawrence also said his agency could determine how attacks on one industry impacted the larger war economy and, by extension, its war effort at the fighting fronts.

There was already a clear sense among the participants at this meeting that city bombing would not do the trick. The Germans were tougher than that, and the Nazi regime was fanatical and unwilling to surrender. Bufton himself had long sparred with Harris over the future role of Bomber Command; whether, for instance, it would evolve

³¹ AIR 14/1216, "Minutes of the Meeting held at Air Ministry on Monday, March 1st 1943, to discuss the possibility of evolving a new method of damage assessment," 14 March 1943, 1.

³² Ibid., 2.

into a precision-bombing force or simply stay as it was.³³ The upshot of these collective ideas was a push by the senior leaders within each BDA-producing command and agency to devise new report formats capable of describing the effects of precision as well as area raids. By the time the transportation and oil offensives began a year later, the new formats were in place to measure the accuracy, effects, and effectiveness of Allied bombing, for individual missions and in the aggregate, with precision.

Having agreed on these important requirements, however, the commands and agencies in question still had a good bit of coordinating to do before they all understood how each would interact with the others to produce these new reports. As we have already seen, RE8 developed and led a 10-step process for assessing the effects of city-attacks and compiling them in Bomber Command's Damage Dossiers. Now, similar processes were needed to produce the new reports. This involved coordination on difficult issues and sometimes required changes at one agency to assist another's efforts to develop a new report. One case in point was a cooperative effort between the ACIU and MEW to provide one another information they needed to turn out reports of aggregate damage to various target sets and to the overall German war effort. In October 1943, ACIU K Section replaced its older and more detailed damage assessments (known as "K" Reports) with shorter ones in a format MEW found less useful and less informative for putting together its aggregate BDA reports. To resolve the issue, the ACIU commander recommended that MEW send requests for detailed damage information only for those specific targets required in their production of aggregate

³³ For Bufton's views on precision bombing, see Webster and Frankland, *Strategic Air Offensive*, Vol. I, 422.

assessments. Once ACIU K Section had these specific requests, they would then produce special supplements to their K Reports specifically for MEW analysts to use in their work. The two organizations also agreed that MEW analysts would in turn review all draft KS (repair and reconstruction) reports for ACIU K Section and provide input prior to publication. In this fashion, ACIU and MEW analysts helped one another produce more focused and useful products.³⁴ This process repeated itself for other reports and resulted, by 1944, in a combined BDA capability that brought together subject-matter experts from all the intelligence agencies to prepare reports that kept senior leaders apprised of the results of Allied bombing.

During the earlier stages of this process, as Americans began to arrive in large numbers, the British provided the photointerpretation expertise required to gauge the effects of 8th Air Force daylight bombing. Fortunately for both parties, the visits by Majors Cabell and Hutchison in 1941 had already paid huge dividends in the establishment of the Army Air Forces Air Intelligence School with its photointerpreters' course, which gave American interpreters the basic skills they needed to begin working immediately as junior partners within existing British organizations. This proved vital to the success of the combined BDA effort. The British were relieved that, given the Americans' willingness to fit into existing British operations, the ACIU would *not* have to change radically to accommodate the Americans' arrival. In fact, a British report later remarked that "our Allies, who adapted themselves admirably to the existing frame-work and collaborated whole-heartedly in the reconnaissance and interpretation effort...were

³⁴ AIR 40/1171, Memo, MEW to ADI(Ph) via A.I.3.c(1), 17 November 1943; AIR 40/1171, Memo, Officer in Charge ACIU to ADI(Ph), "K Reports," 23 November 1943; AIR 40/1171, Minutes, CIU-MEW-AI3c(1) Meeting to Discuss K Reports, 9 December 1943.

well equipped on arrival and were not long in taking full advantage of the operational experience of the British Units.”³⁵

Cooperation in the reconnaissance arena was equally crucial to the development of an effective BDA process for American bomber sorties. From the outset, British PRUs flew BDA sorties for 8th Air Force. By 1943, all American requests for reconnaissance cover went directly to ADI(Ph) at the Air Ministry, which prioritized all such requests from British and American customers. ADI(Ph) exercised operational control over the PRUs and the CIU by putting in place centralized requirements-management and collection-management processes. To make this effort as effective as possible, Eaker wrote to Portal, reminding him that that the Northwest African Air Force reconnaissance capability was already a combined operation and worked very well. He proposed that reconnaissance and photointerpretation be structured the same way in Great Britain. “American Photo Reconnaissance and Photo Interpretation activity,” Eaker said, “must be closely integrated for control and coordination with similar British agencies.”³⁶ He proposed that USAAF photointerpreters continue to work alongside their experienced British counterparts at the ACIU; that a full-time American liaison officer work at ADI(Ph) to field, submit, and track American requests; and that the 13th Photographic Reconnaissance Squadron be based at Mount Farm to be as close as possible to the PRUs and CIU. Portal agreed.³⁷ By September, these procedures, already in place for nine months, were codified in a USAAF instruction that stated all American requests for aerial

³⁵ AIR 40/1816, Air Ministry, *Photographic Intelligence during the European War*, 30 June 1945, 5-6.

³⁶ Spaatz Box 122, Memo, Eaker to Portal, “Proposed Operation of USAAF Photographic Reconnaissance,” 30 January 1943, 1.

³⁷ *Ibid.*, 2.

photography were to be mailed direct to ADI(Ph) via courier. Time-sensitive and urgent requirements for reconnaissance cover could also be made via secure phone call.³⁸

In October, the Bomber Command and 8th Air Force intelligence directorates (Int. 1 and A-2) met to determine how best to produce and share BDA reports of mutual interest. They discussed four topics: coordinating requests for, and providing one another with copies of, photographs taken by each country's reconnaissance sorties; provision of rapid reports from pilots of reconnaissance sorties to the other country's intelligence directorate; the rapid sharing of bomb plots and other BDA-related materials produced at both British and American flying units and headquarters; and the proper division of labor for producing long-term records of bomb damage. The meeting produced agreement on all these issues. The result was a daily meeting between the intelligence directorates to apprise one another of all the reconnaissance sorties they had laid on with ADI(Ph) for post-strike BDA cover and determine the sorties in which both had an interest. For these sorties, they gave each other duplicate copies. This daily coordination process extended to the provision of bomb-fall plots and aircrew debriefings, resulting in a very efficient and highly integrated BDA process from the unit level to headquarters.³⁹

As this coordination progressed, more Americans arrived. The British accepted an offer to station a 61-man USAAF Photographic Squadron at the ACIU. They saw that American requirements for photos, including post-strike cover, were increasing rapidly, and they were determined to satisfy them. However, with their own Photographic Section fully employed, they decided to teach the Americans standard ACIU procedures

³⁸ Spaatz Box 122, 8th Air Force, "Directions for Submitting Requests for Photo Reconnaissance, 9 September 1943, 1.

³⁹ AIR 14/1216, Bomber Command, "Notes on meeting held at Pinetree on 13th October, 1943 to discuss the provision of information from Damage Assessment Sorties of mutual interest," 13 October 1943.

for developing, marking, and distributing photos. As the ADI(Ph) noted, "I feel sure that it would take less time to show the Americans how to produce the material than to be couched with the responsibility of producing the material ourselves."⁴⁰

American photointerpreters were also fast learners. The 1st Photo Intelligence Detachment (1st PID) became so effective that by summer 1943 it provided specialized damage assessments for RE8 analysts to use as they prepared detailed BDA reports. This was significant because RE8 BDA reports were the gold standard, and the analysts who wrote them required the best inputs. The fact that American photointerpreters met RE8's high expectations was a reflection of the superb instruction received from their British counterparts and of their own excellence. An even more fundamental sign of 1st PID's importance was a decision by 8th Air Force senior officers to move the unit from RAF Medmenham to RAF Pinetree. The move proved beneficial because once K Section joined the 1st PID at Pinetree in May 1944, the entire 1st-phase BDA apparatus was located next door to the British reconnaissance squadrons at Benson and the USAAF units at Mount Farm. This resulted in faster production and dissemination of K Section's Immediate Interpretation Reports, which meant flying units, headquarters, and target-selection boards such as the Transportation Targets Committee, the Joint Oil Targets Committee, and the Combined Strategic Targets Committee (more insights on these committees in subsequent chapters) received BDA information in a matter of hours. This proved to be a major force multiplier for Allied bombing campaigns in 1944-45.⁴¹

⁴⁰ AIR 40/1172, Memo, ADI(Ph) to D. of I. (O), "Offer of Personnel from U.S.A.," 11 March 1943, 2.

⁴¹ Spaatz Box 137, Memo, 8AF A-5 to 1st PID, 13 October 1943; Spaatz Box 122, Memo, 1st PID to 8th AF A-2, "Report on Photographic Interpretation Requirements in the Eighth Air Force," 2 August 1943.

The 8th Air Force staff was also cooperating more closely with RE8, where 14 of 63 people assigned in August 1943 were American. The numbers continued to increase. In addition, 8th Air Force was becoming more reliant on targets and BDA products authored by an American agency, the Enemy Objectives Unit (EOU), at the American Embassy in London, which worked closely with the Air Ministry, RE8, and MEW.⁴²

8.3 The ACIU at Maturity: Key Work Sections and Their Duties

The arrival of large numbers of Americans at the ACIU brought it to maturity by 1944. From their initial role as apprentices, American interpreters and photographic officers quickly transformed the ACIU from a British to a combined operation. By June 1943, 70 Americans were working at Medmenham in several of the ACIU's 28 Sections with another 20 en route. Another 67 Americans of the 1st PID were working at RAF Pinetree. Americans were present in all the BDA-related Sections by early 1943. These included 1st-Phase Sections collocated with reconnaissance units to produce Immediate Interpretation Reports; 2nd-phase Sections at Medmenham, including K (Damage Assessment), D (Industry), and F (Transportation) Sections; and at RAF Pinetree, where 1st PID provided 2nd-phase BDA for USAAF heavy bomber raids as K Section did for Bomber Command missions. In May 1944, K Section joined the 1st PID at Pinetree, resulting in a highly-skilled combined Section producing 2nd-phase BDA for heavy bomber raids during the oil and transportation offensives.⁴³

⁴² Spaatz Box 186, Memo, RE8, "American Personnel in R.E.8," 5 August 1943, 1-2; Spaatz Box 290, "Liaison with Air Ministry," 8 September 1945, Located in USSTAF A-2, "History of Directorate of Intelligence, United States Strategic Air Forces in Europe, January 1944 – May 1945," 5.

⁴³ Spaatz Box 122, USSTAF, "History of Photo Intelligence in the U.K. insofar as it Pertains to British-American Cooperation," 22 May 1944, 1; AIR 40/1172, "Central Interpretation Unit, R.A.F. Station, Medmenham," and accompanying organizational chart, 8 June 1943.

By June 1943 K Section photointerpreters, including several Americans, were establishing standardized procedures for 2nd-phase damage assessments. The rigorous standards for this process were clear in instructions issued to K Section interpreters:

In drawing up such summaries the Section has been instructed that all statements are to be statements of fact, or deductions which are supported by the facts which the interpretation has disclosed. No statement which is a matter of opinion, or relates to matters of which the interpreter can have no knowledge is to be made. In particular no adjudication on the success or the failure of an operation is to be made. [However,] it is felt that the value of the P.I. reports will be diminished if men of high intellectual caliber are debarred from stating the results of a careful and detailed study of the information obtainable—a study which no other officer is in a position to make.⁴⁴

This guidance left no doubt as to the high standards demanded of K Section interpreters and emphasized their authority to make reasoned statements about the results of their studies.⁴⁵ These BDA experts, who increased in number from nine in 1940 to 54 in 1944, produced K reports, which were standard damage assessments, and KS reports, which assessed German rubble-clearance and repair efforts and included target illustrations showing damage to specific buildings. They also produced KR reports to address requests for specialized assessments. By 1944, each K Section damage assessment was going to between 30 and 485 addressees depending on the specific report.⁴⁶

⁴⁴ AIR 40/1172, Memo, ACIU to ADI(Ph), "Report K.S.87A," 29 June 1943, 1-2.

⁴⁵ This was in stark contrast to German policy, which was never to allow their photointerpreters, all of which were noncommissioned officers, to make assessments, in spite of their high intellectual and professional capacities. Only the officers commanding German photointerpretation units, who rarely had any training or deep knowledge of their own, were allowed to make judgments of this sort, and they were often wrong. See AIR 34/62, Air Ministry, "The German Photo Reconnaissance and Photo Intelligence Service," September 1945, 12. In a telling comparison of German and British photointerpretation methods, the report said "...interpretation was regarded...as a process of merely recording what was seen on a photograph...the interpreter's duty finished when he had stated what he saw. He was not permitted to make any evaluation of the intelligence he had gained. This evaluation was the duty of the *Bildoffizier* [Photographic Officer]...There is no doubt that much information may be missed by this method. One has only to think of the many instances of intelligence discovered at A.C.I.U. by interpreters drawing their own conclusions from their materials and following up these conclusions on later covers."

⁴⁶ AIR 34/84, Historical Report, ACIU K (Damage Assessment) Section, September 1945, 1.

The next ACIU 2nd-phase office involved in BDA work—D (Industry) Section—tracked every known industrial facility in the Reich and the occupied lands, whether operational or under construction. Photointerpreters in this shop, who numbered two in May 1941 and 25 by 1944, examined every aerial photograph taken of Europe, looking for new facilities or changes to existing ones. They maintained a card index with several thousand entries, each providing the name of the facility, what it produced, the town where it was located, its exact coordinates, and a list of all photographic cover by sortie number, print number, date, and quality. The Section was divided into five teams, each responsible for one of the following industry groups: iron, steel, non-ferrous metals, and electronic equipment; engineering, including motor transport (MT) and armored fighting vehicle (AFV) production, ball-bearings, and textiles; oil, coal, coke, and gas; electric power including dams; and chemicals, explosives, synthetic rubber, and plastics.⁴⁷

Each working group produced detailed interpretation reports and diagrams with the key buildings and components at each facility, which were used at the Air Ministry, Bomber Command, and at other ACIU Sections to produce target materials and BDA reports. From the fall of 1943 much of D Section's work was devoted to the production of reports on the activity of industrial plants. While such reports were issued for all installations, most addressed activity at oil plants, oil refineries, oil storage depots, and tank factories. This is significant given the timing of these efforts, which began eight months *before* the start of the oil campaign and three months before senior airmen began discussing the possibilities involved in a concerted attack on German oil production.⁴⁸

⁴⁷ AIR 34/84, Historical Report, ACIU D (Industry) Section, 25 September 1945, 1.

⁴⁸ Ibid.

Representatives of the section were also attached to the Joint Oil Targets Committee, the AFV Targets Committee, and the Jockey Committee (which selected targets for attack in the German aircraft industry), all of which were ultimately subsumed by the Combined Strategic Targets Committee (more on this in Chapter 10). They also recommended priorities for the attack of targets within each industry based on their level of output and any previous damage they might have suffered. During the oil offensive, D Section analysts worked closely with their K Section counterparts on damage assessments, providing the insights required to make reasoned judgments about the level of activity at each plant or refinery after an attack, and, if the facility was knocked out of action, the amount of time required for repairs to bring it back on line at 25, 50, 75, and 100 percent of pre-attack capacity. Of course, photointerpreters involved in making these judgments maintained daily telephone contact with British and American headquarters and flying units who had an interest in them. They also sent a constant requests for reconnaissance cover of various recently-bombed facilities to ADI(Ph) and later the JPRC so they could keep close track of repair efforts and the likely date at which a given plant would once again become operational. Needless to say, such plants often received a return visit from Allied bombers just as they were about to begin producing again. To facilitate this process during the oil offensive, D Section interpreters built a board listing each oil target, the dates it had been attacked, dates of latest reconnaissance cover, its target-priority ranking, and a note on its operational status. They devised similar boards for AFV targets, and for coke oven plants. These produced benzol, an alternative fuel for German vehicles, and were of interest to the Joint Oil Targets Committee.⁴⁹

⁴⁹ Ibid., 2.

Photointerpreters from D Section also worked closely with analysts at RE8 to produce a vital targeting and BDA tool known as the Target Vulnerability Note. Together, D Section and RE8 produced several hundred of these, each for a specific high-value target such as an oil plant or marshalling yard. Each provided a summary of target characteristics, key components that had to be damaged or destroyed to reduce or stop production, and the best combination of bombs and fuses. One such note, on the Bergius-process oil plant at Pölitz, listed gas generators, compressors, circulators, and injectors as key components to be destroyed, and recommended 500-lb. bombs as the ideal weapons for such a target. To illustrate the plant's key components, RE8 analysts included an ACIU diagram of Pölitz, which provided a numerical reference and brief explanation for every building. Once the oil offensive began, the ACIU and RE8 used this same diagram to denote previous damage (shaded in blue) and damage caused by the latest raid (shaded in red). This cooperation was another example of the cooperation between BDA-producing agencies and commands in the Anglo-American air intelligence community.⁵⁰

The last 2nd-phase office heavily involved in BDA work was F (Transportation) Section, which began with seven people in 1941 and grew to 15 in 1944. The head of section was a railway expert in civilian life who had been drafted, given sufficient rank, and put in charge, a story repeated many times at the ACIU, which hired civilians with deep knowledge of various industries. By September 1941 the Section had produced assessments of all major railroad and inland waterway targets to include the level and type of activity as well as overall importance. When the bombing of railroads, bridges, viaducts, and canals in France and Belgium began in March 1944 in preparation for

⁵⁰ RG243, E16, B21, RE8, "Target Vulnerability Note, Bergius Plant, Poelitz," July 1943, 1-4.

Overlord, F Section interpreters had already studied the effects of raids flown against these kinds of targets in 1943 and were able to assess damage with great accuracy. Like their counterparts in D Section, they worked closely with K Section to ensure necessary details on the damage inflicted by bombing made it into K reports. They also worked directly with the Transportation Targets Committee to choose the highest-priority targets for attack based on their pre-attack importance and the effects of previous bombing raids on their operational capability. Finally, they worked very closely with a little-known but vital intelligence organization, the Railway Research Service, which led the BDA effort for the transportation offensive against the French and Belgian railroads. In 1944 and early 1945, F Section also produced over 500 illustrated and annotated reports on railroad and waterway targets for use in the production of target materials and BDA reports.⁵¹

Despite their less substantial role in the BDA process, other ACIU Sections did get involved from time to time. One of these was L (Aircraft and Aircraft Industry) Section, which provided some crucial targeting and BDA insights. One of these was the discovery that an 8th Air Force raid on the FW-190 factory at Bremen in April 1943, which had caused serious damage but also claimed 16 B-17 heavy bombers and their crews, had bombed an empty facility. The Germans had previously dispersed production from Bremen to Marienburg and a number of smaller plants. This discovery made future targeting and BDA efforts more effective because it got interpreters looking for signs of dispersal and taught them how to recognize the indicators of such activity.⁵²

⁵¹ AIR 34/84, Historical Report, ACIU F (Transportation) Section, 18 June 1945, 1-5.

⁵² AIR 34/84, Historical Report, ACIU L (Aircraft and Aircraft Industry) Section, 20 September 1945, 1-2; Babington Smith, *Evidence in Camera*, 157-160.

Although I have mentioned them previously, N (Night Photography) and Q (Enemy Decoys) Sections deserve another mention. In the case of N Section, which had two people assigned in 1942 and 25 in 1945, cooperation with night photography experts at Bomber Command's Int. 1 unlocked the secrets contained in night strike photographs. They became adept at "plotting by fires," determining the direction and degree of "creep back," and confirming the presence of decoy fires (in conjunction with Q [Enemy Decoys] Section), flak batteries, and searchlights. These abilities proved vital to the provision of BDA for British night city-attacks. An indication of the growth of this effort can be gleaned from the number of night strike film canisters brought back by bomber crews: 1,000 in 1942, 4,000 in 1943, 10,000 from January 1944 to VE Day.⁵³

Two other ACIU offices of note were R1 and R2 (Combined Operations) Sections, which engaged in targeting and BDA with and for the Special Air Service teams that played such an important role in organizing and supplying the Maquis (French Resistance) in 1944. This interaction proved vital to BDA efforts during the Normandy campaign and the breakout and pursuit across France because SAS and Maquis teams provided real-time BDA inputs and also carried out vital attacks on German fuel supplies, trains, barges, and other logistical assets, which worked very effectively in conjunction with Allied bombing raids on marshalling yards, bridges, viaducts, and canals.⁵⁴

From a command and control perspective, the Technical Control Office (TCO) also deserves mention. This office fielded production requests from outside agencies, first via ADI(Ph), and, beginning in May 1944, from the JPRC. A subordinate body known as the

⁵³ AIR 34/84, Historical Report, ACIU N (Night Photography) Section, 26 September 1945, 1-3.

⁵⁴ AIR 34/84, Historical Report, ACIU R1 and R2 (Combined Operations) Sections, 24 September 1945, 1-2. This cooperative ACIU-SAS BDA effort will receive additional attention in Chapter 9.

Progress Section logged in and prioritized all production requests, tasked ACIU Sections to complete them, checked the progress of orders, assembled and confirmed the quality of all completed jobs, and dispatched them via courier to the customers. By 1944, there were an average of 350 orders received, and a similar number dispatched, every day.⁵⁵

By the end of the war there were 566 officers and 1,186 other ranks assigned, nearly 700 of whom were British and about 1,050 Americans. The Print Library contained 6.5 million prints stored on 2.5 miles of shelves. The Photographic Section handled 60,000 tins of film per month and had several multiprinters capable of producing 1,000 photos per hour.⁵⁶ Although the ACIU had not yet grown so large in 1943, it was essentially mature and capable of providing BDA reports to hundreds of customers within hours. These reports also provided a foundation for the detailed 3rd-phase damage assessments produced at RE8 and MEW. By summer 1943, the ACIU had developed the human talents and procedures necessary to provide BDA required by Bomber Command and 8th Air Force, both of which used huge numbers of these assessments once the CBO began.

8.4 The Intellectual Infrastructure: Gauging Effects and Effectiveness

From the summer of 1943 to the spring of 1944, American heavy bombers and their fighter escorts (once they received drop tanks in January 1944) took the air war to the Luftwaffe in an effort to gain air supremacy over the Reich. The battle was long, costly, and at times teetered on the edge of failure, but in the end the Americans gained the victory, and with it air supremacy not only over the Reich, but also over Normandy prior

⁵⁵ AIR 34/84, Historical Report, ACIU Technical Control Office, 1 October 1945, 1-2; AIR 34/84, Historical Report, ACIU Duty Intelligence Office, September 1945, 1-2; AIR 34/84, Historical Report, ACIU Progress Section, 25 September 1945, 4.

⁵⁶ AIR 34/703, ACIU, "Photographic Record of the Allied Central Interpretation Unit," June 1945; Powys-Lybbe, *The Eye of Intelligence*, 9.

to Operation Overlord. During this huge battle of attrition, BDA experts honed their analytical skills, not only by assessing damage to aircraft factories and ball-bearing plants, but also to marshalling yards, oil plants, and other high-value targets, all of which received at least occasional attacks during 1943. This was ideal practice for BDA efforts in support of the 1944-45 transportation and oil offensives.

The progress of the USAAF daylight offensive against aircraft factories and ball-bearing plants during the summer and fall of 1943 has been recounted in many scholarly works. Although the unescorted raids resulted in high losses, they also demonstrated that USAAF aircrews could bomb with remarkable accuracy given good weather conditions. Even more important, as Albert Speer noted in a postwar interrogation, they posed a grave threat to the German war economy. Speer said "The American attacks, which followed a definite system of assault of industrial targets, *were by far the most dangerous. It was in fact these attacks which caused the breakdown of the German armaments industry.*"⁵⁷ The 1943 campaign, which was not capable of doing the kind of decisive damage Speer emphasized, nonetheless served notice of things to come with several attacks against German aircraft factories, including the FW-190 plant at Marienburg, the Me-109 factory at Regensburg, and ball-bearing plants at Schweinfurt.

The raids were nearly all characterized by two things: exceptional bombing accuracy and heavy losses. The accuracy resulted from the intensive training bombardiers, navigators, and pilots received prior to flying operational missions; from the outstanding target materials that included Aiming Point Reports produced by the Enemy Objectives

⁵⁷ MS16, S5, B12, F11, ADI(K) Report No. 349/1945, Interrogation of Albert Speer, "The Effects of the Allied Bombing of Germany," 11 July 1945, 6. Emphasis in original.

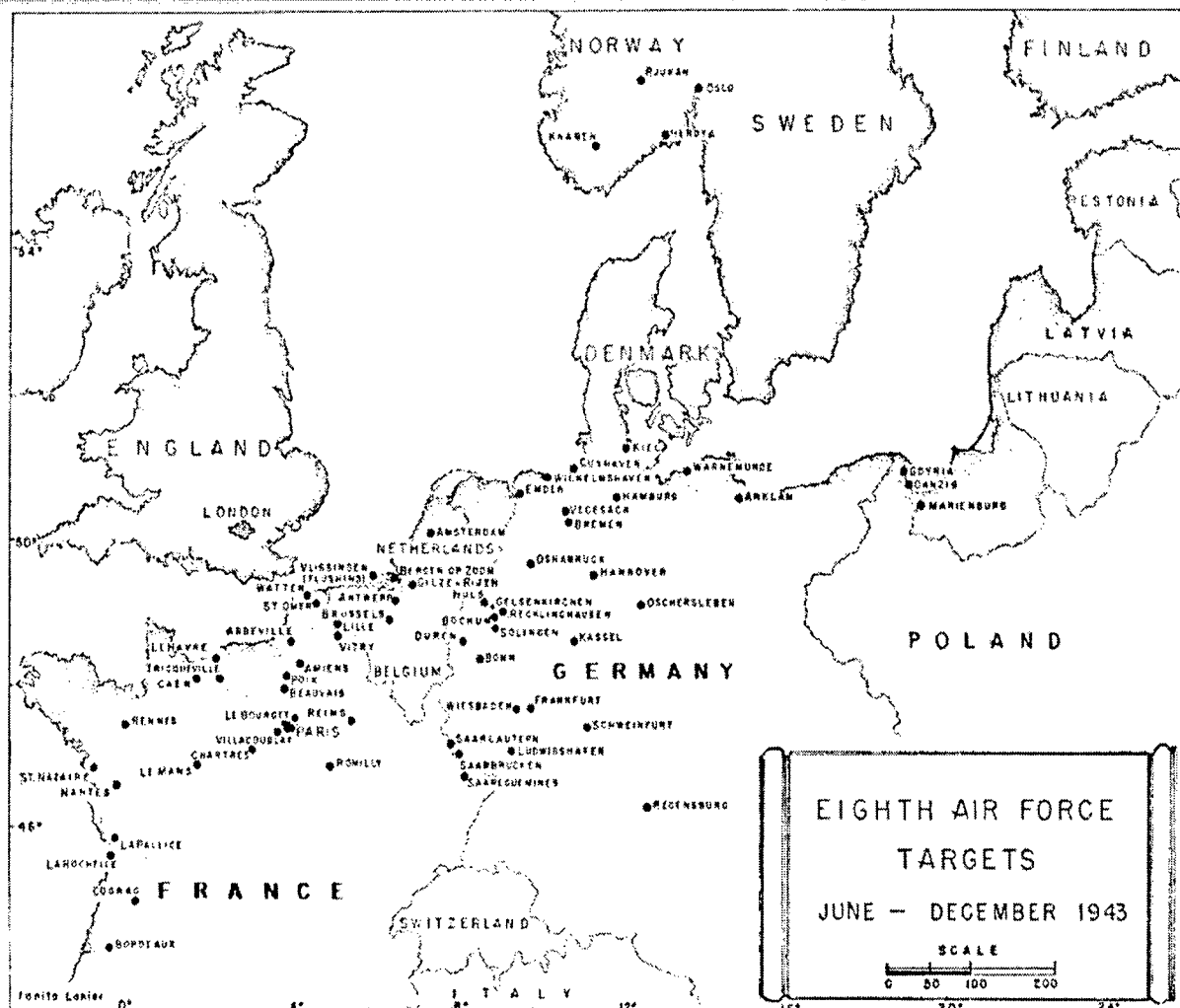


Figure 8.1: Eighth Air Force Targets, June – December 1943

Source: W. F. Craven and J. L. Cate, eds., *The Army Air Forces in World War II, Volume II, Europe: Torch to Pointblank, August 1942 to December 1943* (Washington, D.C.: Office of Air Force History, 1983), 667.

Unit (EOU) at the American Embassy in London; Target Vulnerability Notes authored by RE8; and detailed target maps, charts, and diagrams provided by Bomber Command Int. 1 and the ACIU; and from the Norden bombsight.⁵⁸ The losses resulted from a flawed doctrinal statement that heavy bombers could fly unescorted to and from their targets without incurring excessive losses. This proposition proved disastrously mistaken and placed the entire daylight bombardment effort in jeopardy after the heavy losses incurred during the Schweinfurt and Regensburg missions.

Nonetheless, photointerpreters recognized just how accurate USAAF bombing could be given the proper conditions. The 9 October 1943 attack on Marienburg, for instance, did such severe damage to the plant that it produced no new aircraft until February 1944, and by then the Americans were able to return with much larger numbers of bombers, now escorted by P-51 fighters. Virtually every building at the factory, including the five large structures where new aircraft were assembled, was either destroyed or severely damaged, and over 100 FW-190s in various states of construction destroyed. During this attack, 58 percent of bombs fell within 1,000 feet of the aimpoint, and 83 percent within 2,000 feet. Major General Eaker referred to this raid as “the classic example of precision bombing.”⁵⁹ This was clearly a case in which bombing had been accurate, produced dramatic effects, and had proven highly effective in terms of its contribution to the attack

⁵⁸ For examples of Aiming Point Reports and Target Vulnerability Notes, see RG243, E16, B21, EOU, Aiming Point Report, Villacoublay, 25 June 1943; RG243, E17, B20, EOU, Aiming Point Report, Messerschmitt A.G., Regensburg – Obertraubling, 7 January 1944; and RG243, E16, B21, EOU, Aiming Point Report, Ball Bearing Plants, Kugelfischer, Schweinfurt, Germany, 7 June 1943.

⁵⁹ RG341, E217, B114, ACIU K Section, “Interpretation Report No. K.1776, Marienburg,” 14 October 1943; RG341, E217, B156, ACIU K Section, “Interpretation Report No. K.S. 583, Marienburg,” 23 February 1944; James Parton, *“Air Force Spoken Here”: General Ira Eaker and the Command of the Air* (Maxwell AFB, AL: Air University Press, March 2000), 313-314.

on the Luftwaffe's sources of new aircraft. Attacks continued for several months, and the Germans kept trying to put the pieces back together, but doing so became more difficult with each attack, and although they eked out small numbers of aircraft, catastrophic fuel and pilot shortages made these efforts largely pointless by July 1944.

One particularly significant trend BDA experts noted as the attacks on aircraft and ball-bearing industries intensified in the summer and fall of 1943 was a tendency to disperse production as bomb damage increased. An RE8 assessment of repairs at eight German aircraft factories attacked during the latter half of 1943 noted, for instance, that repairs at Marienburg and Regensburg amounted to only 28 percent of total damage inflicted, with similar totals for the other factories. Reconnaissance cover of the eight plants led RE8 analysts to make several vital conclusions about what was happening within the German aircraft industry as a result of USAAF bombing. First, even the most severely damaged plants, such as Marienburg with the loss of 70 percent of its buildings' square footage, received some repairs and began production again, albeit at reduced levels. Second, even light damage often prompted dispersal of production from a central facility to several satellites producing various components. Third, work continued at damaged plants in both undamaged and damaged buildings. Fourth, there was a tendency to repair buildings where the most important parts of the production process occurred.⁶⁰

The dispersal of war production, which began as a result of Bomber Command city attacks, accelerated with American attacks on aircraft, tank, and truck factories, most of which suffered heavy damage as a result of accurate American bombing. If we can point

⁶⁰ AFHRA 512.57, RE8, "Reconstruction at German Single-Engine Fighter Factories: Interim Report on Reconstruction of Damage Sustained During the Second Half of 1943," 21 April 1944, 5.

to one decisively important result of Bomber Command and 8th Air Force attacks in 1943, it is this: By forcing the German war economy to disperse to a high degree, they rendered it highly vulnerable to disruption in case of serious damage to the Reich's transportation networks. Although nobody could foresee this second-order effect of Allied bombing, its importance proved fundamental to the rapidity with which the Allies were able to defeat Nazi Germany in 1945 once the Third Reich's railroads and canals lay in ruins and the component parts for Germany's weapons sat idle in factories or on rail sidings.

Yet USAAF bombing in 1943 was not always effective. The dozens of futile attacks on German U-boat bases were one case in point. Attacks on aircraft repair facilities such as Villacoublay Airfield in France, an FW-190 depot, were another. Although losses over Villacoublay were light (it was a "training target" for novice crews because it was easy to bomb and lightly defended), and bombing accuracy excellent, the *effectiveness* of these raids proved low for three reasons. First was the poor return on the level of effort expended. There were other lightly-defended targets more important to the German war effort and more worthy of attention. Second was the Germans' ability to fly lightly damaged FW-190s to alternate depots. Third was the speed with which the Germans repaired key airfield infrastructure. For instance, an RE8 assessment of USAAF attacks on Villacoublay on 14 July and 24 August 1943 indicated that FW-190 repairs had been interrupted for 8-16 weeks. However, ACIU K Section reports, which purported to show a slow rate of repair, in fact showed that the Germans very quickly repaired *just those elements of the airfield necessary for resuming aircraft repairs and test flights*.⁶¹

⁶¹ For instance, see RG341, E217, B68, ACIU K Section, "Interpretation Report No. K.S.105, Villacoublay Airfield," 20 August 1943, and RG341, E217, B115, ACIU K Section, "Interpretation Report No. K.S. 157,

The two raids did destroy between eight and 16 FW-190s at Villacoublay for repairs along with another 16-23 aircraft at the adjacent Heinkel and Junkers repair shops. These totals appear impressive given the fact that the Americans lost no bombers on either mission, but when viewed in light of the risks involved, ordnance expended, fuel consumed, and the plethora of better targets in France, their effectiveness was questionable at best. A United States Strategic Air Forces in Europe (USSTAF) report emphasized the rapid repair capability for airfields and made clear that attacks on such targets might produce tangible effects, but would not be *effective*:

Some doubt exists as to the long term value of bombing the installations even on a...repair base. The enemy has manifested marked capacity for the rapid restoration of necessary facilities and for temporary improvisation. Villacoublay was a case in point. Despite three heavy attacks by 8AF bombers, Villacoublay remained a principal repair facility. Two attacks on St. Dizier met with the same results: heavy damage but rapid repair and return to operational status within a week of each attack.⁶²

Some "precision targets," the USAAF was learning, were not worth the effort required to attack them. They promised at best a modest return on effort, and at worst a diversion of scarce assets on a futile endeavor, something the RAF learned the hard way in 1940-41.

Ironically, other "precision" targets that *were* worth the effort and risk were not attacked often enough to produce decisive results. German ball-bearing factories were a case in point. According to an RE8 report, the first USAAF raid on Schweinfurt, on 17 August, caused a 15 percent loss in production and a similar loss of finished product at the three major factories, which produced over 70 percent of Germany's ball-bearings.

Villacoublay Airfield," 2 December 1943. In both of these reports, it is very clear that the Germans repaired only what they had to, did so quickly, and were back in the aircraft repair business within a week rather than the 8 to 16 weeks estimated in HO 191/116, RE8, "Raid Assessment Report: Aircraft Repair Shops—Villacoublay, France, Raids of 14th July and 24th August, 1943" October 1943.

⁶² MS16, S2, B3, F5, HQ USSTAF A-2, "An Appreciation of Heavy Bomber Attacks on Airfields in Germany," 25 October 1944, 4.

The 14 October raid did severe damage, including the destruction of the ball-bearing-forming and heat-treatment buildings and the top two stories of the assembly and storage building. The ACIU K Report said:

Very heavy and concentrated damage is visible within the target area, due probably as much to fire as to H.E. All three factories of the Schweinfurt ball-bearing industry and the two closely allied therewith have been affected, those of the V.K.F. Werks I and II suffering very severe damage. In many cases, buildings damaged in the previous raid have now been destroyed or have received further damage.⁶³

The ACIU photointerpreters were clearly impressed. In fact, they seldom used phrases such as "very severe damage". An RE8 report estimated losses at three months of ball bearing production and seven weeks for roller bearings. Yet RE8, not yet fully cognizant of the dispersal of German industry, based these assessments on an assumption that all damaged buildings and machinery would be replaced on site. The Germans chose to disperse instead, which got them back in production more quickly than RE8 estimated but also made their production vulnerable to any disruption in the transportation system.⁶⁴

It also became clear after the war that damage had been more severe than RE8 estimated. During a postwar interrogation, officials from the Kugelfischer Company stated that the raids had reduced ball bearing production at Schweinfurt by 50 percent, but that repair and dispersal brought production back to 80 percent of the pre-attack level. (Notice that the plant and its dispersed satellites never returned to 100 percent of pre-attack production, an indication the raids did grievous damage.) They also noted that repeat raids, while too infrequent, kept production at 40-75 percent of the pre-raid total. Speer noted that the Germans had already begun to decentralize ball-bearing production

⁶³ RG243, E27, B145-46, ACIU K Section, "Interpretation Report No. K.1785, Schweinfurt," 20 October 1943, 1.

⁶⁴ RG243, E27, B145-46, RE8, "Raid Assessment Report: Ball Bearing Plants, Schweinfurt, Germany, Raid of 14th October, 1943," 18 November 1943, 1-3, in Target Damage File, Schweinfurt, 1944-1945.

by the time of the first Schweinfurt attack on 17 August, but also said a concerted attack on all sources of production would have been a serious problem.⁶⁵

A cautionary word is also in order about the "precision" bombing of Schweinfurt, which was some of the more accurate of the war. The 228 B-17s making the attack carried 459 1,000-lb. and 663 500-lb. general-purpose bombs, and 1,751 100-lb. incendiaries. Of these 2,873 weapons, approximately 256, or 8.9 percent, hit the buildings or the grounds of the three plants, which totaled 132 acres (0.25 square miles).⁶⁶ This was excellent bombing by World War II standards, but it was far from perfect. Heavy bombers were not rapier-like weapons, nor were the bombs they carried. Both were bludgeons, designed to smash buildings and equipment by massing enough destructive force on a target to do serious damage. An 8th Bomber Command ORS report also noted that damage caused by incendiaries, which burned down 13,500-16,800 square feet of building space, was between three and four times greater than the damage caused by general-purpose bombs, which destroyed about 4,000 square feet of building space.⁶⁷

American accuracy might have been quite good, but losses were excessive, and a period of bad weather lasting until early January 1944 gave 8th Air Force an alibi to stand down and await the arrival of fighter escorts with drop tanks. Nonetheless, a precedent had been set: With good weather, American bombers could do very serious damage to targets deep within the Reich. They would return with a vengeance in January and

⁶⁵ RG243, E31, B1, "USSBS Interview No. 4, Subject: Messrs. Klinger, Walz, Detzel of the Kugelfischer Company," 19 May 1945, 1-3; AIR 20/8779, SHAEF G-2, "Interrogation of Albert Speer, former Reich Minister of Armaments and War Production, 6th Session, 1500-1700 hrs., 30th May 1945," 30 May 1945, 3.

⁶⁶ RG243, E27, B145-46, RE8, "Raid Assessment Report: Ball Bearing Plants, Schweinfurt, Germany, Raid of 14th October, 1943," 18 November 1943, 2, in Target Damage File, Schweinfurt, 1944-1945.

⁶⁷ RG243, E27, B145-46, 8th Bomber Command Operational Research Section (ORS), "Report on the Effectiveness of Bombs and Fuses, Attack of 14 October 1943, Schweinfurt," 2 November 1943, 1-2.

February 1944, and every month thereafter, to prove this again. Perhaps the greatest accomplishment of these unescorted USAAF raids in 1943, along with Bomber Command's city attacks, was the impetus they gave the Germans to disperse their industries, making them vulnerable to transportation attacks in 1944-45.

The dispersal of German industry had yet another cost not recognized until 1944. It was described most clearly by a German airman, *Oberstleutnant* Kogler, who prior to his capture in January 1945 was an FW-190 pilot and *Kommodore* (Commander) of *Jagdgeschwader 6* (a German *Geschwader* was larger than a USAAF Group but smaller than a Wing). Kogler emphasized the profoundly negative impacts of dispersed aircraft production on Luftwaffe operational capabilities. Because each small factory produced only one or two components, often under poor conditions, the quality of these parts was low and their failure rate high. Even worse, components had to be shipped to a central assembly point and put together without an effective quality-control process. As Kogler said, "It was a Sisyphean task, which had now become necessary."⁶⁸ He continued:

Then came the dark side of this mass-production, and above all this production in primitive workshops under unimaginably unfavourable conditions. In September [1944] I started to re-equip the first 'Gruppen' of my 'Geschwader,' and to bring up the strength and to equip the second 'Gruppe' which was already in operation against the invasion. The 'Gruppen' were brought up to a strength of about 60 to 70 aircraft and a corresponding number of pilots, and then the re-training started. During the re-training I lost the following: six excellent pilots killed, a large number seriously wounded, and between 40 and 50 aircraft, I can no longer remember the number exactly. Only because of technical defects. Each time a 'Gruppe' went to a so-called 'Gruppe' training flight, I had to count on probably one killed and two, three, four, or five emergency landings of which a certain number of aircraft had to be written off because they were damaged... Those were conditions which of course

⁶⁸ MS16, S5, B12, F12, Combined Services Detailed Interrogation Center (CSDIC) United Kingdom (UK), Report No. SRGG 40, "Lecture on the German Air Force given by CS/1190—Oberstleutnant KOGLER to his fellow Senior Officer PW on 15 Mar 45," 15 March 1945, 9.

did not contribute towards raising the pilots' self-confidence or strengthening their confidence in their aircraft.⁶⁹

These catastrophically high loss rates *in training* (remember these pilots and aircraft were not lost in combat, but during the standard flight-training program) stand as a stark testimony to the hidden costs of dispersed production. Kogler also noted that the damage done to the ball-bearing plants and reserve stocks at Schweinfurt forced the Germans to use sleeve bearings rather than ball-bearings in the crankshaft of the FW-190D's Diamler-Benz 603 engine. This led to a great deal of engine trouble. Kogler closed his sobering narrative with a summary of his unit's combat experience, which lasted precisely two days because every pilot except Kogler was killed or wounded and their aircraft badly damaged or destroyed. Two suffered complete engine failure *before* they even made it into combat with the Americans.⁷⁰

What Kogler described here, though he would not have used the term, were the "cascading effects" of American bombing raids. The bombing caused severe damage to aircraft factories and ball-bearing plants, which forced the Germans to disperse. These were what U.S. Air Force officers today would refer to as first-order and second-order effects. The aircraft manufactured in this dispersed production program were of poor quality and had a number of potentially deadly defects. These were third-order effects. The fourth-order effects occurred when the aircraft malfunctioned, often catastrophically, driving up pilot losses in training and combat. As a result of these excessive loss rates, surviving pilots had less confidence in their aircraft and themselves, and lower morale. These were fifth-order effects. As the current Air Force term suggests, these effects

⁶⁹ Ibid., 11.

⁷⁰ Ibid., 11-13.

“cascaded” down from the bombing of German aircraft and ball-bearing plants.⁷¹ They were all serious and resulted collectively in a crisis for the Luftwaffe, one of several brought on by Allied bombing, including very high loss rates of both aircraft and pilots in combat, and a catastrophic fuel shortage once the oil offensive began in May 1944.

The role of BDA reports in all of this was crucial because they demonstrated that “precision” attacks could do severe damage. As numerous sources, including Kogler’s testimony, gradually revealed the magnitude of the crisis caused by dispersed aircraft production, Allied intelligence officers were able to confirm that Allied bombing raids on these plants had dramatic *effects* and were also profoundly *effective*. Even more fundamentally, BDA reports such as Kogler’s (and it *was* a BDA report in everything but name), which became increasingly plentiful and detailed in 1944, gave Allied airmen increasing confidence in the efficacy of their bombing raids.

As the American bombing campaign intensified, so too did efforts to improve bombing accuracy through the development of new tactics. The 8th Air Force ORS engaged in a study of bombing operations from 1 January through 15 October 1943 that achieved this goal. Using a sample of 205 raids employing standard combat-box formations, ORS analysts determined that the mean accuracy of missions from 1 January to 15 May was 11.3 percent of bombs within 1,000 feet of the aimpoint and 24.6 percent within 2,000 feet. From 1 August to 15 October, the figures improved to 13.0 and 28.7 percent, respectively. They also noticed a major improvement in accuracy for missions with pre-assigned common aimpoints. The figures here were 16.7 percent within 1,000

⁷¹ As will become clear in the following chapter, the concept of cascading effects was present in the planning, execution, and damage-assessment processes for both the transportation campaigns and the oil campaign. See Chapter 9, note 23, page 13 for a more detailed look at this key concept.

feet of the aimpoint and 36.4 percent within 2,000 feet for the earlier period, while for the later period they were 21.9 percent and 48.5 percent. The most dramatic improvement, however, occurred as USAAF bombardment groups adopted Colonel Curtis LeMay's lead-navigator concept, in which the crew with the best navigator and bombardier determined the point at which all aircraft on a given mission released their ordnance, bombing on the lead crew's radio or flare signal. Using this system, mean accuracy in the 1 January to 15 May period was 27.0 percent within 1,000 feet of the aimpoint and 59 percent within 2,000 feet. In the 1 August to 15 October period, the figures were 28.7 percent within 1,000 feet and 63.5 percent within 2,000 feet. By the end of 1943, the lead-navigator method, practiced at the bombardment group level, became the standard for 8th Air Force and 15th Air Force. Dropping on the group's lead navigator also tended to produce smaller and more compact bombfall patterns, which also translated into a more bombs within 1,000' of the aimpoint.⁷²

The downside of this assessment was that accuracy declined rapidly for the second and subsequent groups because smoke from the lead group's bomb detonations obscured the target. Groups bombing first averaged 23.4 percent of bombs within 1,000 feet of aimpoint, while the overall average was 13.4 percent. The rule here was simple: the more groups attacking a target, the less accurate each succeeding group's bombing. The percentage of gross errors (when the center of an aircraft's bomb pattern missed the aimpoint by over 3,000 feet) also rose rapidly for each successive group over the target: 10 percent for the first group, 39 percent for the third, and 72 percent for the fifth. Even

⁷² RG243, E36, B2, 8th Air Force ORS, "Analysis of VIII Bomber Command Operations from the Point of View of Bombing Accuracy, 1st January 1943 – 15th October 1943," 31 October 1943, 17-23.

here, however, there was good news. Spacing each successive group's time over target by between one and five minutes resulted in dramatic improvements in accuracy. In fact, this spacing of groups improved the 3rd group's accuracy by 124 percent, the 4th group's by 158 percent, and the fifth group's by 370 percent. Overall accuracy for bombing with spacing of groups over the target was 21.9 percent of bombs within 1,000 feet of aimpoint as opposed to 13.4 percent without spacing, a 63 percent improvement. By reducing gross errors dramatically, this tactic drove major improvements in accuracy.⁷³

One other important area of tactical development revolved around the employment of blind-bombing aids such as H2S Mark III (the British navigation and bombing radar) and H2X (the American version). Once the heavy losses of August-October and the subsequent bad weather conspired to keep the Americans from flying any more unescorted raids prior to January 1944, Eaker pushed his scientific staff of 8th Bomber Command, several of whom were on loan from the Radiation Laboratory at the Massachusetts Institute of Technology, to transition H2X from a testing mode to an operational one. As Eaker said, "I believe the ultimate requirement for heavy bombers operating in this Theater is one operational blind bombing squadron per combat wing. This would allow the maximum use of all airplanes and secure more effective bombing by employing two operational H2X airplanes per group."⁷⁴ He was not looking for a way out of "precision" bombardment, but for a means to bomb during the bad weather of fall and winter. Although H2X bombing allowed the USAAF to go after targets regardless of weather, it drove up bombing errors and civilian casualties, despite Eaker's assertion that

⁷³ Ibid., 25-29.

⁷⁴ Spaatz Box 231, Memo, Eaker to Giles, 7 December 1943, 2.

the USAAF should never be accused of “throwing the strategic bomber at the man in the street.”⁷⁵ Operational employment of H2X increased rapidly after January 1944. By war’s end nearly 51 percent of all American bombs had been dropped using H2X, rather than visual bombing, a little-remarked statistic with serious BDA-related ramifications.

8.5 Finishing Touches: The Joint Photographic Reconnaissance Committee (JPRC)

The last major piece of the Anglo-American BDA capability to reach maturity—and it was a vital one—was the formation of the JPRC to track the hundreds of requests for photographic cover pouring into ADI(Ph) at the Air Ministry each day by late 1943. Although ADI(Ph) had done an admirable job administering this effort, it was clear by the end of 1943 that its staff was too small to continue in the role. In the spring of 1944, Brigadier General George C. McDonald, Director of Intelligence (A-2) for the newly-formed United States Strategic Air Forces Europe (USSTAF) under the command of General Carl Spaatz, pushed his boss to meet with the British to develop a more responsive tasking and dissemination system for reconnaissance, photointerpretation, and the products they yielded. Just before this, Air Vice Marshal Inglis, the Air Ministry’s Assistant Chief of Air Staff for Intelligence, had written Spaatz on the same subject, advocating improvements to the existing process. Spaatz concurred, and Inglis replied enthusiastically but emphasized one potential sticking point. Although Spaatz preferred a fully integrated tasking and dissemination capability, Colonel Elliott Roosevelt, his chief reconnaissance officer, had instead told Inglis that Spaatz wanted a *separate* American CIU with an independent tasking process. Inglis warned Spaatz that such a move would

⁷⁵ Spaatz Box 16, Minutes of U.S. Strategic Air Forces (USSTAF) Air Commanders’ Conference, 15 October 1944; Spaatz Box 20, Memo, Eaker to Spaatz, 1 January 1945.

have a deleterious effect on 2nd and 3rd Phase photointerpretation work, which the Americans were unable to provide on their own, and which the British would also be unable to provide if all Americans working in the ACIU were withdrawn and placed in an American-only CIU. Inglis instead sought improvements to the combined framework within which the Allies conducted their reconnaissance and photointerpretation work.⁷⁶

Inglis need not have worried. When Spaatz met with McDonald, Roosevelt, and Air Commodore Grant (Inglis's action officer), he made it clear that he wanted an improvement of the combined framework as a means for tasking and disseminating photointelligence. He further noted that he wanted each American numbered air force (including 8th and 15th) to be self-contained in all phases of photography, photo interpretation, preparation of target folders, and weather reconnaissance. Spaatz said the immediate photointerpretation done at flying units was crucial because it allowed for effective planning of the following day's sorties. Nonetheless, he stated explicitly that improvements at the numbered air forces and flying units would be made without removing Americans from the ACIU or any other Anglo-American operation focused on the production and dissemination of BDA reports. This capability, which had already proven vital to the Allied bombing effort, was safe and would continue to flourish.⁷⁷

After his meeting with Spaatz, Grant proposed to Inglis and to Group Captain F. C. V. Laws, Deputy Director of Photography, that the Mediterranean Allied Photographic Reconnaissance Center (MAPRC), already highly successful, serve as the model for the JPRC in Great Britain. He also suggested the Americans, who now had very substantial

⁷⁶ Spaatz Box 122, Memo, Inglis to Spaatz, 11 March 1944; Spaatz Box 122, Memo, McDonald to Inglis, 16 March 1944; Spaatz Box 122, Memo, Inglis to Spaatz, 19 February 1944.

⁷⁷ Spaatz Box 122, Minutes, Meeting of Spaatz with AC Grant, Brig Gen Curtis, Col McDonald, and Col Roosevelt, 2 March 1944.

reconnaissance and photointerpretation capabilities in theater, have an equal share in the tasking authority for strategic reconnaissance assets. Finally, he recommended that a board of army, navy, and air force officers from each country be established at the JPRC to receive collection requests and assign priorities to them. Following this brief period of intensive staff work, the two allies agreed to establish the JPRC, effective May 1944. It worked closely with No. 106 Group, which controlled all British PRUs and the ACIU, and with the 325th Reconnaissance Wing, which controlled all American reconnaissance and photointerpretation assets in theater.⁷⁸ This centralized control facilitated the rapid receipt, tasking, and dissemination of customer requests and products, most of which, by this time, were BDA reports.⁷⁹ The original directive, written by the British, said the JPRC "will be a Sub-Committee of the Joint Intelligence Sub-Committee, responsible to them through the British Chiefs of Staff, and will be under the Chairmanship of the former Assistant Chief Intelligence Officer (Photographic)."⁸⁰ However, the Americans saw through this British effort to keep operational control of the JPRC to themselves. Once this disagreement was ironed out, the JPRC, under combined operational control, went into action on 26 May 1944. It proved to be an essential, timely, and effective organizational evolution in support of the BDA effort.⁸¹

The process for tasking photoreconnaissance and photointerpretation assets was concise and effective. The JPRC could reject collection requests, order them filled by existing coverage, or task them for first-, second-, or third-priority collection. Approved

⁷⁸ MS16, S5, B12, F5, Memo and Paper, Inglis to McDonald, 23 May 1944.

⁷⁹ Spaatz Box 122, Paper, D. of I. (O) to D.D. Photos, 4 March 1944; Spaatz Box 122, Memo, Inglis to McDonald, 17 March 1944.

⁸⁰ Spaatz Box 122, "Operational Directive No. 1, No. 106 Reconnaissance Group," 14 May 1944.

⁸¹ AIR 40/1816, ACIU, "Notes on P.R. and P.I. Procedure," 21 February 1945.

requests were sent to the Photoreconnaissance Requirements Section of the JPRC on a Form Green, which contained the required job number and priority, the target to be photographed, the scale of photography, whether it was to be flown by an aircraft of 106 Group or 325th Wing (decided in consultation with liaison officers from the two units, both of whom worked at the JPRC), and the required action to be taken by ACIU to produce intelligence in the requested format. All information on the Form Green was recorded on an index card and placed in a card index. The card recorded actions taken at the ACIU to provide the required intelligence. Given their importance, BDA photographs and associated reports were generally tasked as first-priority jobs.⁸²

Once the Form Green was complete copies went to the tasked photoreconnaissance unit, the ACIU, and the ACIU Photographic Interpretation Section (PIS) at RAF Benson, which was responsible for 1st-phase BDA reports. After the aircraft returned from its collection mission, the Photographic Section at RAF Benson developed the film and made two complete sets for the ACIU Cover and Plotting Sections and the Central Library, one complete set for K Section at RAF Pinetree, and one to the ACIU PIS at RAF Benson. While the PIS completed 1st-phase BDA (Immediate Interpretation Reports) within three hours of receipt of photos, K Section produced the more detailed K-series damage assessments over the course of the next 12 hours. The first report provided "the basics": did the bombers hit their targets, how severe was the damage, and what was the photointerpreter's initial take on the raid's effects? The K-series reports provided much greater detail, including specific buildings and machinery hit, the assessed degree of damage, loss of production, and, if the facility was out of action, the estimated repair

⁸² Ibid., 1-2.

time required to bring it back on line at 25 percent, 50 percent, 75 percent, or 100 percent of pre-attack capacity. Before completing the Immediate Interpretation Reports, PIS interpreters provided key observations immediately by secure teleprinter and telephone based on examination of the negatives as they came out of the developing solution. These first insights went to the JPRC, targeting boards, headquarters, and flying units.⁸³

At the ACIU, the Technical Control Office received and recorded all Forms Green, distributed the jobs listed on them to the appropriate ACIU Sections, and ensured the required work progressed at the necessary tempo. This involved checking his job card file frequently, annotating completed jobs, moving cards to jobs-completed file, and hastening work on remaining jobs through contact with various ACIU Sections. As the various ACIU Sections completed jobs, the finished products went immediately by courier to the customer.⁸⁴

8.6 Technologies, Technicians, and Techniques: The Sinews of BDA

The Anglo-American air intelligence capability at the heart of the BDA effort during the Second World War rested on a number of vital technologies, technicians, and techniques that had their start in the Great War and came of age between 1940 and 1944. At the most basic level, BDA depended on aircraft capable of penetrating enemy airspace and cameras taking photos with adequate ground detail to be of use to photointerpreters. Fortunately, the British excelled in both these arenas, particularly in the development of high-speed, high-altitude aircraft, and the Americans in the invention of superb cameras and film. The importance the Allies came to place in these technologies becomes evident

⁸³ Ibid., 3-5.

⁸⁴ Ibid.

when we consider that British reconnaissance missions averaged 100 a month in 1940 but 1,110 in April 1945. By 1945, the Americans contributed another 1,000 or more sorties per month. The total number of reconnaissance missions flown from the start of the war to VE Day is not known, but the Anglo-American total for the period January 1944 to VE Day was well in excess of 125,000 sorties, and we may surmise that they flew perhaps 75,000 sorties from January 1940-December 1943, which means an aggregate figure of around 200,000 sorties. Each of these, if successful, brought back 1,300-1,650 negatives, each covering about two square miles of the earth's surface. This meant an average sortie produced photographs covering *3,000 square miles* of territory. Another indication of the magnitude of this effort was the fact that, by the end of the war, the ACIU Photographic Section had produced *over 30 million* prints, many for the BDA effort.⁸⁵

By August 1940, the 20 Spitfires in service with PDU were penetrating deep into the Reich, obtaining the first cover of Berlin (a roundtrip distance of 1,550 miles) and other major cities. In fact, the British very quickly photographed every industrial and military installation in Germany and occupied Europe. By 1942 the Mosquito had joined the reconnaissance force. It had greater range, more cameras, and an observer, which allowed for better navigation and target location. The "Mossie" could cover targets as far east as Poland, East Prussia, Silesia, and Austria. At the same time, the PRU established an Operational Training Unit for its new pilots. Only veteran pilots with superior flying skills were accepted. Their training represented a major investment in time and treasure. Consequently, as the loss rate climbed in late 1941 with the Germans' introduction of the

⁸⁵ AIR 40/1816, Air Ministry, *Photographic Intelligence during the European War*, 30 June 1945, 3-4; Spaatz Box 274, USSTAF A-2, *The Contribution of Air Power to the Defeat of Germany*, Appendix M, Miscellaneous Aspects of Air Power," 1 August 1945, 1-2.

Bf 109G, which was optimized for high-altitude intercepts, the British took countermeasures. These included installation of better engines and pressurized cabins.⁸⁶

This process began in late 1941 with the installation of the Merlin 45 engine in the Spitfire. As losses once again began to mount in early 1943, the British fitted the Merlin 61 engine with a two-stage supercharger on all their reconnaissance Spitfires and Mosquitoes. This engine gave the new Spitfire XI and Mosquito IX (both operational by spring 1943) combat ceilings of 41,000 and 36,000 feet. In late 1943, the Mosquito PR XVI appeared. It was the first Allied reconnaissance aircraft with a pressurized cabin, allowing it to operate from altitudes well above 40,000 feet. Once the Me-163 and Me-262 began taking a toll on reconnaissance aircraft in 1944, the British introduced the Spitfire PR 19. It had a 2,035 horsepower Griffon engine, a pressurized cabin, and a combat ceiling of nearly 50,000 feet, which placed it at the limits of the operational envelope for piston-engine aircraft but above the operating altitude of the Me-262, which resulted in a decrease in loss rates from around 2 percent of sorties to nearly nil.⁸⁷

These impressive operational altitudes came together with the F.52 camera and its 36-inch lens, which provided 1:13,000-scale resolution from 40,000 feet of altitude. This allowed photointerpreters to determine the type of traffic on railroad sidings, the state of construction of individual U-boats, the layout of radar installations, and a wealth of other intelligence not previously discernable on aerial photographs taken from such high altitudes. American cameras of even greater precision joined the F52 by 1943. The K-18 provided the largest rectangular images (9x18 inches) and could take 250-260 images per

⁸⁶ AIR 40/1816, Air Ministry, *Photographic Intelligence during the European War*, 30 June 1945, 4; Price, *Targeting the Reich*, 9-11.

⁸⁷ Price, *Targeting the Reich*, 20-23.

roll of film, while the other principal US camera during WWII, the F-17, could take 450-500 9x9-inch photographs. Both the K-17 and K-18 had 40-inch lenses. The K-19, which was optimized for night photoreconnaissance, combined with the electric strobe flashes pioneered by George Goddard, allowed the Allies to keep an eye on key German activities and facilities around the clock. These superb American cameras, used by both the Americans and their British allies, comprised the primary USAAF technological contribution to the BDA intellectual infrastructure.⁸⁸ Unfortunately, the American contribution on the aircraft front—the F-5—was mediocre at best.

On a brighter note, however, American photointerpreters proved that, with proper training, they were as capable as the British. By 1944, these photointerpreters were part of a large and expert group of air intelligence specialists providing a wealth of vital BDA data. Over 2,000 officers and enlisted personnel were working at the ACIU and its Mediterranean equivalent by this point, and the numbers would increase steadily until early 1945, when the ACIU alone had over 1,750 personnel assigned and the Mediterranean CIU another 500 or so. The Americans had drawn nearly even with their British allies in terms of the expertise they brought to the BDA effort, mostly as a result of British tutelage once they had completed their courses at AAFAIS (and from 1944 at the Intelligence Division, School of Applied Tactics, Orlando, Florida). The quality of instructors and materials at the American schools was quite good by 1944.⁸⁹

The Americans, of course, took their lead from the British, who by 1944 were masters of their trade. British senior leaders did four vitally important things in their

⁸⁸ Price, *Targeting the Reich*, 21; Stanley, *World War II Photo Intelligence*, 153-156.

⁸⁹ Powys-Lybbe, *The Eye of Intelligence*, 9.

efforts to build an effective corps of photointerpreters. First, they gave the CIU *carte blanche* in hiring the most qualified civilians to fill these billets. Second, they put these people in the positions that best suited their talents. Third, they put them through a rigorous training program that included both formal training in the schoolhouse at Nuneham Common and on-the-job training at the CIU. In fact, British photointerpreters were not considered journeymen in their trade until they had completed a year-long apprenticeship with CIU veterans. Fourth, and most importantly, the ACIU's leadership held their photointerpreters to the most rigorous professional standards and at the same time gave them the authority to make reasoned judgments about what they discovered in the photographs they studied. The ACIU had priority in recruiting skilled people from a variety of locations, including the Cambridge University archaeology department, where the CIU had first pick of the detail-oriented archaeologists whose job it was to make connections between the patterns and clues they saw in the fossil record. Other professions included professors of geology and botany, distinguished painters and sculptors, photogrammetrists, photographers, town planners, and writers.⁹⁰

The Americans followed the British lead in picking and training photointerpreters. In fact, an Army Air Forces Air Intelligence School (AAFAIS) manual emphasized that

A good photo interpreter is an individual who has patience, a flare for detail and a highly retentive memory. He should be an inquisitive person and one who is not easily discouraged by lack of full success...The educational and civilian backgrounds that have been found most conducive to good interpretation are those of a scientific nature. Research-minded men and women have proven to be the most successful in this field. Extensive travel and a general knowledge of our economic world are important to the production of good photo interpreters. Certain fields of endeavor that lend themselves to photo interpretation are these: Photogrammetry; Structural and Economic Geology; Industrial Architecture; Civil and Chemical

⁹⁰ Powys-Lybbe, *The Eye of Intelligence*, 9, 46.

Engineering; Soil Erosion Control and Forestry; and those biological fields that involve microscopic study...⁹¹

The British would have added an additional emphasis on candidates from creative disciplines in which pattern recognition was important, including art, sculpture, and archaeology. In fact, the Americans had a large number of people from artistic and creative fields on the faculty at the AAFAIS. Of the 94 faculty members teaching at the school in January 1944, 11 were either professional or avid amateur photographers—no great surprise given the school's mission. Others included a professor of biology and anthropology, three professors of geology, one of whom also worked as a paleontologist and another who enjoyed oil painting (a pastime he shared with four other faculty members), an architect whose hobby was archaeology, a graduate of the Yale University School of Photography who listed his hobbies as landscape photography and nuclear physics (an interesting if somewhat unusual combination), a design studio expert, and a construction engineer. When viewed in its entirety, the list of professions and hobbies is stunning in its collective level of expertise and creative talent.⁹²

The Americans also took their cue from the British when it came to apprenticeships for their photointerpreters. "After school training," the AAFAIS manual said,

interpreters should serve an apprenticeship in several or all units of a Central Interpretation Section. Those who develop a general all-around proficiency and speed make excellent officers for Forward Interpretation Units [stationed at combat headquarters such as 8th and 15th Air Force]. Interpreters who evidence desire and ability to specialize in a particular field should be assigned to duty with the Central Interpretation Section.⁹³

⁹¹ SMS376, Army Air Forces Air Intelligence School, Photo Intelligence Division, "Photo Intelligence for Combat Aviation," November 1943, 1.

⁹² SMS 376, Army Air Forces Air Intelligence School (AAFAIS), Staff Directory, 1 January 1944, 54.

⁹³ SMS376, Army Air Forces Air Intelligence School, Photo Intelligence Division, "Photo Intelligence for Combat Aviation," November 1943, 2.

The school itself was also demanding, and the washout rate was high, with as much as 15 percent of each class washing out. As rigorous as the basic course was, however, it was never as tough as the British version, which failed over 20 percent of each class.⁹⁴

The Americans also borrowed British course material and compiled it into an instructional manual still useful today for understanding what photointerpreters were expected to learn and how they interacted with combat intelligence officers at flying units. The manual noted that each bomb group had two interpreters assigned. Their key job was to interpret bomb strike photos taken by cameras on board the bombers. The bomb plots produced by photointerpreters were defined as “an annotated print which shows the location of each bomb impact in the target area.”⁹⁵ Along with Strike Attack Reports, bomb plots provided a preliminary statement of a mission’s success or failure. For crucial missions, photointerpreters immediately sent a teletype message to all interested parties in advance of their written reports, which went to the wing, bomb division, numbered air force (8th or 15th), and USSTAF. A copy also went to the PID and to K Section at RAF Pinetree for use in the production of formal BDA reports. Once the reports reached 8th and 15th Air Force, interpreters assigned there compiled a master bomb plot for each mission.⁹⁶ Other information in the report came from the combat intelligence officer, including the number of aircraft participating in each raid, the number and type of bombs used, altitude of bomb run, axis of attack, and aimpoint. Photointerpreters also gave special target identification briefings to navigators and

⁹⁴ AIR 34/84, Historical Report, ACIU Training Section, “Photographic Interpretation,” 14 September 1945, 1-2.

⁹⁵ SMS190, S2, B3, F1, War Department, HQ USAAF, *Handbook for Combat Air Intelligence Officers*, Second Edition (published by AAFAIS), March 1944, 56.

⁹⁶ Ibid., 73; SMS376, Army Air Forces Air Intelligence School, Photo Intelligence Division, “Photo Intelligence for Combat Aviation,” November 1943, 5-7.

bombardiers, highlighting key geographical features to assist them in navigating to the target and making the bomb run.⁹⁷

Photointerpreters working at the bombardment groups and all higher echelons were required to have a good working knowledge of the German target systems they had to analyze. The AAFAIS manual for photographic intelligence contained a number of detailed and very useful chapters covering the various target sets, their significance, and their key vulnerabilities to aerial bombardment. Chapter IX, for instance, addressed German fuel production, explaining that each ton of coal processed in a synthetic oil plant yielded 40 gallons of gasoline, 50 gallons of diesel fuel, 35 gallons of fuel oil, and 10,000 cubic feet of fuel gas. It then provided detailed insights on every major component of German synthetic oil plants.⁹⁸ This kind of detail was the norm in every section, whether discussing the German transportation network, tank factories, steel mills, or the several other major target systems in the Reich. The manual gave USAAF interpreters a grounding in their discipline before they arrived in Great Britain to work at the ACIU, a bombardment group, or a numbered air force.

8.6 A Mature Intellectual Infrastructure and Prospects for Allied Bombing

By January 1944, the BDA intellectual infrastructure was mature. The technologies, technicians, and techniques required to produce accurate and sophisticated BDA reports were in place, as was the centralized tasking, collection, and dissemination machinery based first on ADI(Ph) and after May 1944 on the JPRC. Photointerpreters at the ACIU had a deep knowledge of the various German target sets, as did their counterparts and

⁹⁷ SMS 190, S1, B1, F1, AAFAIS M-I-191, "Photo Intelligence," Section M-VII-37, "Notes on the Interrelationship of PI and CI," February 1944, 1.

⁹⁸ Ibid., 3.

BDA coworkers at RE8 and MEW. They were equally well versed in producing BDA reports for Bomber Command night area raids and USAAF daylight “precision” attacks, and senior airmen recognized their vital role in the Allied war effort and the great utility of their damage assessments for assessing the accuracy, effects, and effectiveness of Allied bombing. The BDA experts and the intellectual infrastructure they had built over the previous four years were poised to support the heavy bomber campaigns senior Allied airmen planned and executed during 1944. And the airmen were not long in letting them know what those campaigns would target.

On the operational side of the bombing effort, the Allies were ready to engage in a series of major air offensives against the Reich and occupied Europe. These offensives had three primary purposes: to win air supremacy in the skies over Europe, to isolate German units in Normandy from their sources of supply and reinforcement in preparation for Operation Overlord and during the ground actions to follow, and to destroy the Third Reich’s oil industry and thereby undermine the mobility and combat power of German ground and air units in the field. They would achieve the first of these objectives during Operation Argument, which effectively destroyed the Luftwaffe by forcing it into air combat with superior American airpower from January to May 1944. The other two offensives were crafted during a series of heated meetings in which the British and their American allies put forth competing plans for the employment of their heavy bombers. Fortunately, they had enough of them—over 4,000 by January 1944—to execute *both* the British and the American plans, the former focused on transportation networks and the latter primarily on oil but with a transportation component. The bomber forces set to these tasks were by now comprised entirely of four-engine “heavies” with veteran crews.

These huge bombing campaigns, which were preceded by a smaller effort against Italy that highlighted both the potential and the limitations of attacking transportation networks as a means for reducing the enemy's ground and air combat power, played a vital role in the defeat of Nazi Germany. And the successes of Allied heavy bombers against the transportation networks and the oil industry at the heart of the German war effort depended very largely on the BDA experts who helped Allied senior airmen steer their heavy bombers to the most lucrative targets. With this in mind, we turn to the first two of these air offensives, against the Italian transportation network in 1943-44, and then against the transportation network in France and the Low Countries during the spring and summer of 1944.

CHAPTER 9

THE FIRST AND SECOND TRANSPORTATION CAMPAIGNS: BOMBING, BDA, AND THE DEFEAT OF GERMAN ARMIES IN FRANCE, 1944

*You must not hold the childish opinion that danger from the air will remain as slight as it is today...The next six to nine months will bring the decisive turning-point for us. This... will depend solely upon whether we are in a position to oppose the enemy with more single and twin-engined fighters than he has bombers to put into the air against us...*¹

- Albert Speer to Central Planning Office,
Memos of 12 February and 29 July 1943

*Bombardment operations relating to transport [are] perfectly conceived and realized. If we...had to practice a sabotage of the same character, we would not do any better. Disorganization is progressive and irreparable. The Allies make work necessary and know how to adjust their raids to await the repercussions of previous raids...It would be impossible now to pass a division from north to south or south to north.*²

- Department Head, Northern Region, French
National Railways (SNCF), May 1944

*Additional divisions could never have compensated for the lack of gasoline during the defensive operations in Normandy, and this was equally true east of Paris, in the Siegfried Line, and after the breakthrough to the Rhine. Additional divisions in a traffic desert are always a liability.*³

- Generalfeldmarschall Gerd von Rundstedt,
Commander-in-Chief, Western Front

*We could not have conducted this offensive better ourselves.*⁴

- Oberst Hans Hoeffner, von Rundstedt's Senior Logistician

9.1 Prelude: The Defeat of the Luftwaffe and Intensification of Bombing

In the United States Strategic Air Forces in Europe (USSTAF) postwar history, General Spaatz, the USSTAF commander, noted that the Allied heavy-bomber

¹ AIR 20/8780, Control Commission for Germany (BZ), Field Information Agency, Report No. 62, Interrogation of Albert Speer on "The Effects of Aerial Warfare and Allied Successes on German War Production" (interviewed and provided material on 6 September 1945, 8 November 1945, 2-3.

² AIR 37/719, Railway Research Service (RRS), "French National Railways (S.N.C.F.) Position, June 1st 1944," 10 August 1944, 6.

³ Spaatz Box 272, USSTAF A-2, *The Contribution of Air Power to the Defeat of Germany*, Volume 1, Section 1, 1 August 1945, 3.

⁴ MS16, S5, B12, F12, ADI(K) Report No. 301/1945, Interrogation of Colonel Hans Hoeffner, 1945, 13.

campaigns accomplished three things of vital importance in the Allied victory. The first was achieving air supremacy. This was the result of a long and costly aerial battle of attrition in which the USAAF's heavy bombers and fighter escorts outfought and outlasted their German adversaries. The second achievement was the destruction and dislocation of the German war economy. This involved a direct assault on key German industries, including oil, and also a transportation campaign against the Reich's railroads and canals, which led in early 1945 to a catastrophic disruption in the movement of coal, component parts for various weapon systems, and oil. The destruction of Germany's oil industry and the disruption of her transportation networks also undermined the mobility of German armies and air forces in the field, which Spaatz held to be the third major achievement of Allied heavy bombers and their key contribution to victory. Throughout the document, and in Spaatz's wartime correspondence, there was a clear recognition that heavy bombers would not win the war by themselves, but that they could shorten it significantly and make it much less costly for the Allies—including the Russians—in both blood and treasure.⁵

The BDA reports produced by Allied intelligence organizations during the transportation and oil offensives were central to the success of these major bombing campaigns because they gave senior air and ground commanders a very clear idea of the effects and effectiveness of air operations against these key target sets. By this time, photoreconnaissance, photointerpretation, and the signals intercept of German Enigma messages were coming together in a mature and complementary BDA capability that

⁵ MS16, S5, B12, F12, HQ USSTAF A-2, *The Contribution of Air Power to the Defeat of Germany*, 7 August 1945, 1-2.

allowed the Allies to gauge the effects and effectiveness of their bombing within days or even hours. This was due to the maturation of photointerpretation capabilities in 1943 and early 1944, and even more so to the rapid expansion in the numbers and capabilities of Allied photoreconnaissance units and their centralized control under the JPRC.

In late 1942, all the British PRU squadrons received new 500-series designations: No. 540 Squadron (Mosquitoes), and No. 541, 542, and 543 Squadrons (Spitfires). Each of these had between 15 and 20 aircraft. On 15 May 1944, they became part of the 106th Wing, which combined with the ACIU to form the 106th Photographic Reconnaissance Group. Similarly, American reconnaissance squadrons and photointerpretation units in Great Britain became part of a new parent unit, the 7th Photographic Reconnaissance Group, in August 1943. The group was subordinate to 8th Air Force but was tasked by ADI(Ph) and later the JPRC. By September 1943 the 7th Group had four squadrons attached, each with 16 aircraft. When General Spaatz took command of the newly-formed USSTAF on 20 January 1944, he chose Colonel Elliott Roosevelt, son of the President, to command the new 8th Reconnaissance Wing (Provisional), which included the 7th Group and the new 25th Group.⁶ In August 1944 this unit was renamed, becoming the 325th Reconnaissance Wing. The Mediterranean Allied Photo Reconnaissance Wing (MAPRW), formed in January 1944, subsumed Northwest African Allied Air Forces and its theater-level Mediterranean Photographic Intelligence Centre (MPIC), which was modeled on the ACIU. The 5th Photo Group, assigned to 15th Air Force in October 1943, provided BDA photos for MPIC photointerpreters to analyze. This Mediterranean

⁶ Spaatz Box 290, "Photographic Reconnaissance and Intelligence," 1. The 8th Reconnaissance Wing (Provisional) was established by General Orders Number 69, HQ 8AF, on 18 February 1944. Roosevelt commanded the wing and also acted as photographic staff officer to General Spaatz.

portion of the BDA infrastructure assessed the effects and effectiveness of the crucial raids against Ploesti as oil targets in southern Germany, Austria, Czechoslovakia, and Poland. Taken together, these reconnaissance units had over 270 aircraft assigned.

This superb reconnaissance capability came together in a highly synergistic fashion with the world's best signals-intelligence and cryptographic units at Bletchley Park, and later with ground-survey teams collecting BDA at captured facilities, to give the Allies a deep knowledge of the German war effort and its vulnerabilities. Indeed, by the spring of 1944, very little of significance happened in the Reich and occupied Europe without being observed, analyzed, and put to use in the Allied war effort. This was particularly true with respect to BDA reports produced for the transportation and oil offensives.⁷

By January 1944, the Allies had the heavy bombers, escort fighters, and air intelligence they needed to take the air war to Germany decisively, and to assess the effectiveness of that effort. With the start of Operation Argument on 24 January, the Americans set out to wrest control of the air over the Continent from their German adversaries. In the air battles that followed, the Americans won a resounding victory. A USSTAF A-2 report highlighted the ferocity and intensity of the campaign against the Luftwaffe and the German aircraft industry. It estimated that nearly 3,700 German fighters had been destroyed and another 1,400 damaged at the cost of 946 bombers and 397 fighters. Although American bombers did serious damage to aircraft, aero-engine, and ball-bearing plants, the decisive factor was the relentless destruction of Luftwaffe fighters and their increasingly under-trained pilots, who were compelled to engage the Americans in a losing effort to protect their sources of supply. During 47 major attacks

⁷ Stanley, *World War II Photo Intelligence*, 62-65.

carried out by 5,166 heavy bomber sorties against the German aircraft industry from January through March 1944, USAAF escort fighters and heavy bombers inflicted such severe losses on the Luftwaffe that it never again posed a major threat to Allied air or ground operations. A simultaneous effort against German airfields also produced excellent results. Heavy bombers and fighter aircraft carried out 95 attacks consisting of 5,367 sorties, destroying over 1,000 aircraft. These attacks also killed a number of pilots and destroyed fuel stores. The Germans could not afford these losses, a fact that took on greater importance with the start of the oil offensive in May 1944. The USAAF's all-out effort, based on General Hap Arnold's orders to Lieutenant General Jimmy Doolittle, commanding 8th Air Force, to "Destroy the enemy air forces wherever you find them, in the air, on the ground and in the factories," made possible the transportation and oil offensives by removing the only barrier to their execution: the Luftwaffe.⁸

As this battle for air supremacy raged in the skies over the Reich, Allied commanders were discussing their options for employing heavy bombers in support of the landings in Normandy. There were two competing plans, one put forth by Air Chief Marshal Arthur Tedder and his scientific advisor, Professor Solly Zuckerman, and the other by General Carl Spaatz.⁹ Tedder, who served as General Dwight Eisenhower's Deputy Supreme

⁸ MS16, S5, B12, F8, HQ USSTAF A-2, "Results of First Three Months Operations," 8 April 1944, 1-12 (there are no page numbers, but this summary occurs in the first 12 pages of text); AFHRA 168.491, vol. 5, memo, Arnold to Doolittle, 27 December 1943. The best accounts of this battle for air supremacy are McFarland and Newton, *To Command the Sky*, and Williamson Murray, *Strategy for Defeat*, which provides a wealth of information on the defeat of the Luftwaffe, including its incredibly high aircraft and pilot loss rates. Murray also reminds us that, aside from inflicting catastrophic losses on the Luftwaffe, the USAAF offensive also forced a major reduction in German fighter strength on all the fighting fronts as the Luftwaffe concentrated nearly 70 percent of its fighters in Germany for the air defense of the Reich. He also remarked that the American air offensive caused a major shift towards fighter production at the expense of bombers, which had profoundly negative ramifications for the German army.

⁹ To put it mildly, Zuckerman had an interesting career. A South African by birth, he traveled to England in 1926 and became an M.D., serving as research anatomist to the Zoological Society of London. While

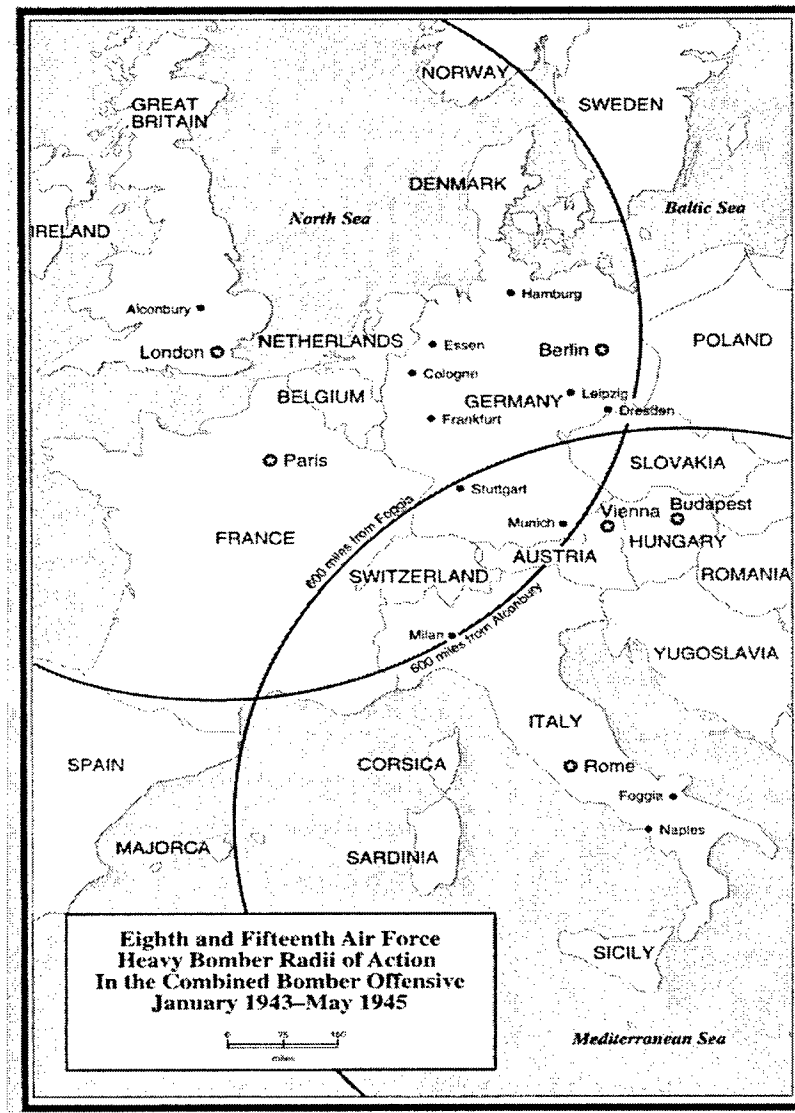


Figure 9.1: Heavy-Bomber Combat Radii from Great Britain and Italy.

Source: Stephen L. McFarland and Wesley Phillips Newton, "The American Strategic Air Offensive against Germany in World War II, in *Case Studies in Strategic Bombardment*, ed. R. Cargill Hall (Washington, D.C.: Air Force History and Museums Program, 1998), 199.

there he wrote *The Social Life of Monkeys and Apes*. Along the way, he married the daughter of Lord Reading, who had served as Ambassador to the United States, Viceroy of India, and finally as Foreign Secretary to Prime Minister Ramsay MacDonald. He also spent two years as a Research Fellow at Yale University and then taught at Oxford. When the war began, he worked for RE8, investigating the wounding effects of various German bombs, which proved to be the start of a distinguished wartime career as Air Chief Marshal Tedder's Scientific Advisor. He set forth these details, and a myriad of insights regarding targeting and BDA for the transportation offensives against Italy, the French and Belgian railroads, and the Third Reich itself in *From Apes to Warlords* (New York: Harper & Row, 1978).

Commander of Allied Forces for the invasion, favored a concerted attack on railroads in France and the Low Countries, with special emphasis on major marshalling yards, to isolate German troops in the battle area from supplies and reinforcements. Spaatz favored an attack on German oil production with a secondary effort against major bridges along the Seine and Loire Rivers. In this way, he said, the Germans would be deprived of tactical mobility *on all the fighting fronts* as their fuel supplies dried up. The bridge attacks would ensure that German forces in Normandy were isolated from their sources of supply and reinforcement. Ike ultimately chose Tedder's plan, but also gave Spaatz permission to go after his preferred targets. Both proposals had their genesis in an earlier effort to isolate German ground forces in Italy by bombing the transportation network upon which they relied for their supplies and reinforcements. The BDA from this first effort to attack an enemy's transportation network played a central role in the later and more successful attempt to do so in France, the Low Countries, and western Germany from March to September 1944.¹⁰

9.2 The Bombing of Italy, BDA, and Plans for Bomber Support to Overlord

Planning for transportation attacks against the Italian railroad network began in the spring of 1943 with a Northwest African Air Forces (NWAAF) A-2 assessment of the Italian railway network and its key vulnerabilities. The report focused on interdicting oil and coal shipments given Italy's dependence on imports for 95 percent of the former and 80 percent of the latter. With this in mind, the A-2 recommended attacks on locomotives and rolling stock to reduce the carrying capacity of Italy's railroads. This meant a focus

¹⁰ The Tedder plan is located in Spaatz Box 114, Air Chief Marshal Tedder, "Employment of Allied Air Forces in Support of 'Overlord,'" 24 March 1944. The Spaatz plan is at AIR 37/1125, USSTAF, Proposal, "Employment of Strategic Air Forces in the Support of Overlord," 24 March 1944.

on large marshalling yards where such assets were always concentrated in large numbers. Also significant was the report's finding that the Brenner Pass carried almost 50 percent of train traffic into Italy and two Swiss lines another 38 percent, with the rest moving over smaller lines from France and Yugoslavia. Interdiction of the Brenner Pass and the two lines entering Italy from Switzerland thus had a high priority from the outset. In fact, the Mediterranean Allied Photographic Reconnaissance Wing (MAPRW) was already busy preparing mosaics and detailed target materials for attacks on these targets.¹¹

The NWAAF A-2 report also provided a detailed assessment of the railroad network, noting that there were three major north-south rail lines: one along each coast, and one through the Appenines from Bologna to Rome. Marshalling yards at Rome and Naples were the bottlenecks in Italy's rail network. In fact, because the east-coast line turned west and headed to Naples, most east coast traffic and all north-south traffic passed through the marshalling yard east of Naples, making this the single most important target. Steam locomotives and two types of electric ones (three-phase and direct current) plied these rail lines. The three-phase locomotives were in short supply and serviced several key routes, including the north section of the Brenner Pass line, which made them excellent targets. Several key transformer stations were also priority targets, as were changeover points where trains switched from three-phase to direct-current power. Finally, rolling stock and locomotive production were both weak and vulnerable to concerted bombing. All locomotive factories were thus on the Allied target list.¹²

¹¹ RG243, E36, B231, NWAAF A-2, "Strategic Analysis of Italy—Rail," 11 June 1943, 1; RG243, E36, B231, NWAAF A-2, "Transportation of German Military Personnel into Italy by Rail," 4 August 1943, 1; RG243, E36, B231, 9625, "Transformer Stations on Italian Electrified Railways," 14 October 1943.

¹² Ibid., 2-4.

By late June the NWAAF air staff and Zuckerman had devised competing plans for attacking Sicilian railroads in preparation for the invasion. Despite the A-2's useful insights on the vulnerabilities of the Italian railroad network, the NWAAF staff's plan instead focused on bombing rail lines, which were not on the A-2's list of key targets. Zuckerman disagreed, focusing instead on marshalling yards in Sicily and southern Italy, including the vital one at Naples. Tedder chose Zuckerman's plan and, once Sicily had been secured by the Allies, sent him off to conduct a ground survey of Allied bombing operations in Sicily and to glean from Italian railroad officials the effects and effectiveness of raids on marshalling yards from Naples and Foggia to Palermo¹³

Zuckerman had worked in the Ministry of Home Security from the start of the war, where he analyzed the effects of German bombing on British industries and railroads. He was also a member of RE8, where he studied damage to German targets. Tedder had hand-picked him to be his scientific advisor; as events were to prove, he chose wisely. Zuckerman began his survey with a careful look at the Italian national railway's records of activity and the damage done by bombing. He came away convinced that attacking marshalling yards was the best way to interdict the movement of troops and supplies. He said of his work in Italy and of later ground surveys in France and Germany:

The purpose of every study I embarked upon was to get a measure of the effectiveness of air attacks in relation to their tactical or strategic purpose. I was not interested just in figures showing the extent of physical destruction; my main concern was whether we could achieve the objectives we were after better next time, either by choosing different targets or by using different methods of attack.¹⁴

¹³ RG243, E36, B231, NWAAF A-2, "Preliminary Summary of Transportation Targets, Southern France," 12 April 1943; Zuckerman, *From Apes to Warlords*, 197-199.

¹⁴ Zuckerman, *From Apes to Warlords*, 209.

Zuckerman set his Bombing Survey Unit of 70 men to work with these goals in mind. What he found as a result of his team's efforts was a strong connection between attacks on major railway centers and the serious logistical problems German ground forces had in the Sicilian and south Italian campaigns. He rated attacks on the key marshalling yards in southern Italy and Sicily (Naples, Foggia, San Giovanni, Reggio, Messina, and Palermo) "an outstanding success."¹⁵

Zuckerman's final report, published in December 1943, said the destruction of locomotive repair shops and rolling stock was the most important cause of German logistical problems, which had clearly hindered the German army's ability to maneuver and fight as supplies of fuel and ammunition became limited and then unreliable. Nonetheless, Zuckerman concluded that the effort had been a "partial failure" because German units could still move and fight, even if in a significantly degraded fashion. His analysis concluded that simultaneous and concerted attacks against major marshalling yards were by far the most effective means for causing major damage to key components such as locomotive repair depots and roundhouses. They overwhelmed repair crews and forced them to prioritize their efforts, leaving several marshalling yards unusable or working at vastly reduced capacity for days or even weeks. Zuckerman also counseled patience. He stated that attempts to achieve immediate dislocation of rail traffic would fail. Disrupting a railroad network, he said, takes time. On the other hand, Zuckerman concluded that neither rail lines nor bridges presented lucrative targets. The former were too easily repaired, and the latter too difficult for heavy bombers or even medium bombers to hit with any regularity. The latter assertion was wrong, but Zuckerman's

¹⁵ Ibid., 210.

analysis otherwise proved correct once put into practice during the transportation campaign against the French and Belgian railroad networks.¹⁶

In preparing his report, Zuckerman had the services of his 70-man Bombing Survey Unit and a wealth of Italian sources. Among these was General di Raimondo, Director of Italian Military Transportation, who noted that attacks on marshalling yards "had been most successful and had seriously delayed rail traffic."¹⁷ From January to September 1943, Allied bombers had destroyed 30,000 wagons and 500 locomotives. He also noted that the major railroad bridge at Bolzano, which had been seriously damaged, was repaired within 40 hours. Zuckerman evidently took this to mean that railroad bridges could be repaired quickly enough to forestall major delays. Spaatz evidently drew the opposite conclusion, looking to the day when heavy and medium bombers could attack bridges several times a day to keep them out of commission. Spaatz proved right here, although Zuckerman was also correct in focusing on key marshalling yards.

As Zuckerman recognized, the limiting factor in bombing the Italian railroad network was not its vulnerability to air attack (it was quite vulnerable), but rather Italy's geography, which allowed the Germans to conduct an effective defense with limited manpower and logistical support, and provided little maneuver room for Allied armies to exploit breakthroughs. Bombing effects against Italian rail centers were significant, but its *effectiveness* was limited because the Germans could always get just enough supplies through to combat units. Nonetheless, both Zuckerman and Tedder recognized the potential effectiveness of a larger transportation offensive against France precisely

¹⁶ Spaatz Box 160, Solly Zuckerman, "Air Attacks on Rail and Road Communications," 28 December 1943, i-v.

¹⁷ RG243, E36, B231, Allied Forces Headquarters Director of Intelligence (G-2), "Interview with General di Raimondo, Director of Italian Military Transportation," 24 September 1943, 1.

because of the geographic differences. While Italian geography made breakthroughs anywhere south of the Po River Valley very difficult, that of France provided opportunities for breakout and large-scale maneuver warfare once beyond the bocage.

Nonetheless, Zuckerman and Tedder had to rely in part on faith, as well as their scientific approach to planning bombing offensives, particularly given the sometimes discouraging BDA reports published during the Allied campaign in Italy. One such study noted that rail attacks could not prevent the enemy from receiving a minimum supply shipment of 4,000 tons per day, 700 tons of which came by sea and the remainder by railway to railheads, and then via motor transport to the front lines. The report's key insight was that, "With the enemy's ability to maintain his minimum requirements under existing conditions, it is appreciated that air attacks on his supply lines cannot produce a critical situation unless his rate of consumption is raised."¹⁸

Even in this pessimistic report, however, Zuckerman saw opportunities. Bombing attacks on rail centers in Italy had pushed railheads 90 miles from the front.¹⁹ This forced the Germans to use their limited supply of trucks and fuel to make long, dangerous, and inefficient night supply runs from the front lines to the railheads and back again. This was the first instance of what Russell Hart called the "demotorization" of German army divisions, which were forced to use their trucks as supply-haulers rather than troop

¹⁸ Spaatz Box 202, HQ MAAF, "Appreciation of Air Attack against Enemy Communications and Supply in Italy," 28 April 1944, 1-2. Although Tedder and Zuckerman had left Italy several months before this report was published to begin planning the transportation campaign in support of Overlord, they already had an understanding of the key issues raised in it based on their constant engagement with BDA-related issues.

¹⁹ The 90-mile distance was from the railhead to the front lines south of Rome. The supply route to other parts of the line could be much longer and more circuitous. See Eaker B I:30, F6, 12759-12761, HQ MAAF, "Allied Strategic bombing," Interrogation of *General der Artillerie* Hartmann, in which that officer said "During the crucial fighting at Cassino, the railroad line from Florence south could not be kept in regular operation, and material had to be brought a distance of 600 kilometers [375 miles] by truck."

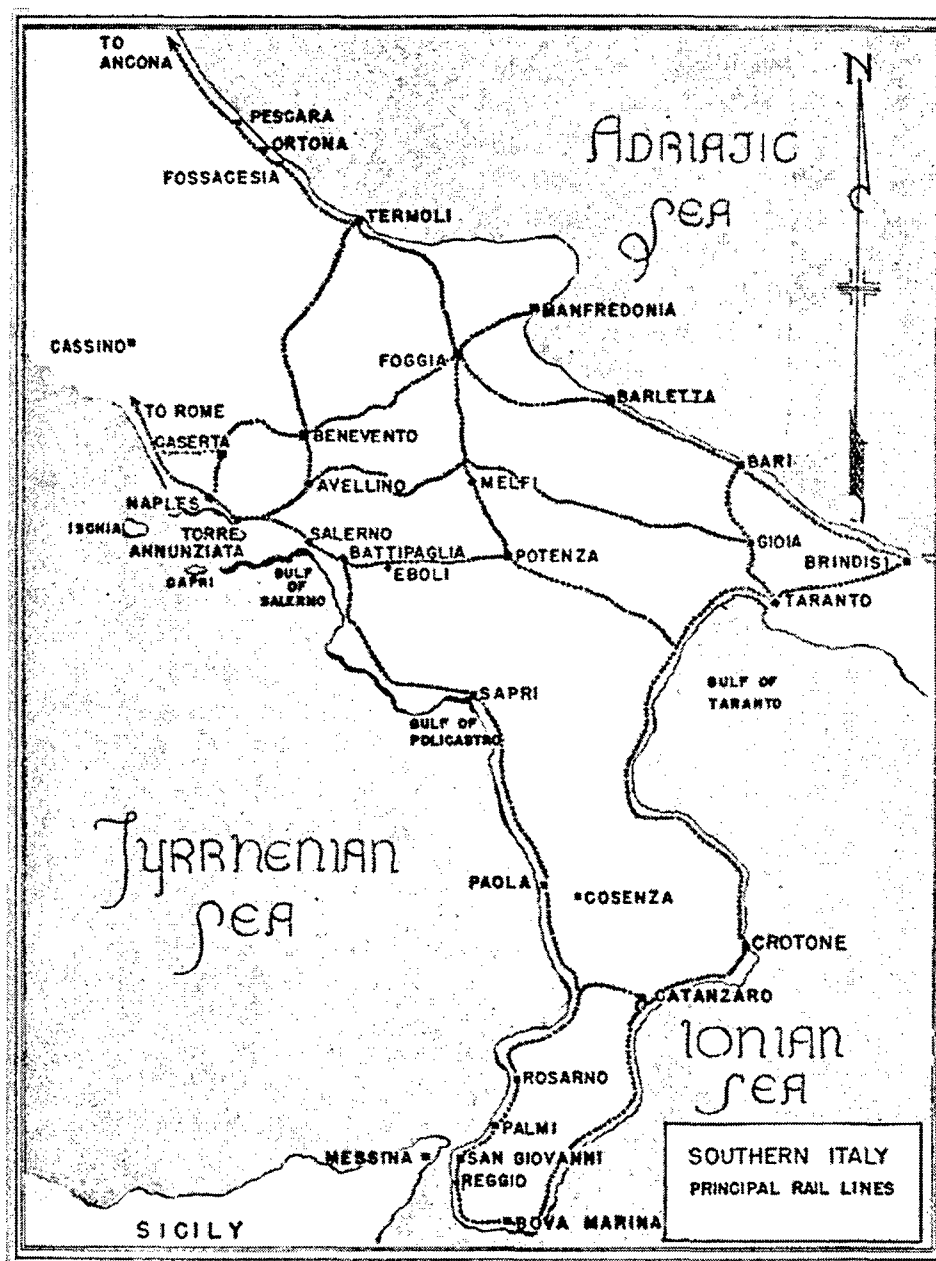


Figure 9.2: Southern Italy's Railroad Network

Source: W. F. Craven and J. L. Cate, eds., *The Army Air Forces in World War II, Volume II, Europe: Torch to Pointblank, August 1942 to December 1943* (Washington, D.C.: Office of Air Force History, 1983), 505.

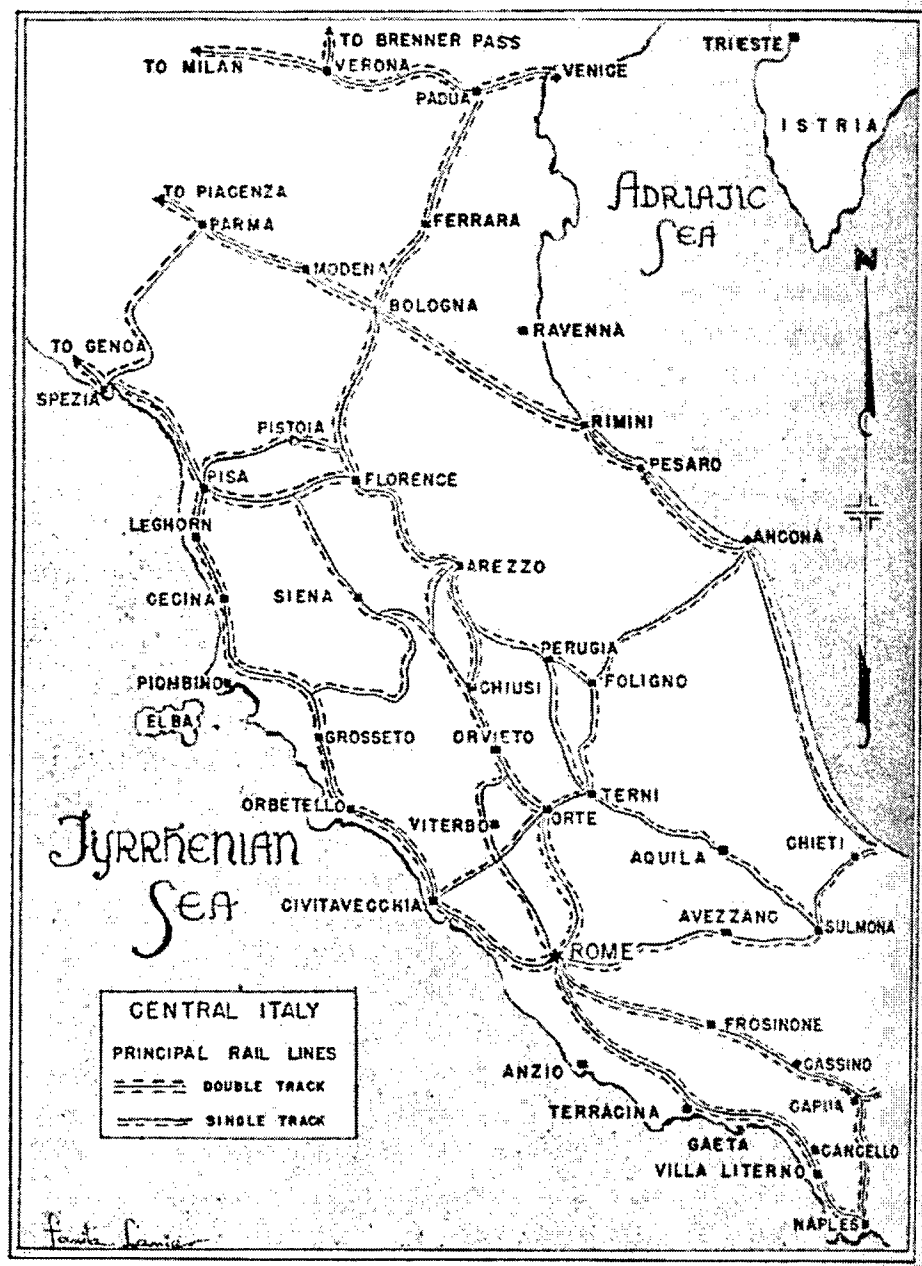


Figure 9.3: Central Italy's Railroad Network

Source: W. F. Craven and J. L. Cate, eds., *The Army Air Forces in World War II, Volume II, Europe: Torch to Pointblank, August 1942 to December 1943* (Washington, D.C.: Office of Air Force History, 1983), 556.

transports.²⁰ This reduced their tactical mobility, created a severe and worsening truck shortage, and forced a heavy use of fuel. The combination of “blackout” headlights, poor roads, and night-bomber attacks all took a toll on machines and men. The result was a loss of 1,500 trucks during the first four months of 1944.²¹ And while the Germans had adequate stocks—if barely—to prevent an Allied breakthrough to Rome until late May 1944, once the Allies broke through and the battle became mobile, German fuel began running out within days. This forced a retreat from the Gustav Line 60 miles south of Rome to the Gothic Line 150 miles north of Rome. Even though the breakthrough in Italy occurred two months after the start of the transportation offensive in France, Zuckerman argued, correctly as events would prove, that the concerted bombing of rail centers in France would facilitate the same sort of Allied victory, but on a larger scale given France’s less difficult terrain.²²

A senior Italian officer had confirmed German logistical difficulties during an interrogation in January 1944, stating that the German supply situation suffered from

²⁰ Russell A. Hart, “Feeding Mars: The Role of Logistics in the German Defeat in Normandy, 1944,” *War in History*, November 1996, 3 (4), 418-435. Although Hart focused on the same issue in Normandy, the first signs of it were present in Italy at least four months earlier.

²¹ An indication of the difference in scale—and potential—of the transportation campaigns against Italy and France is the number of German trucks destroyed: 1,500 in Italy during the first four months of 1944 and 30,000 during the three-month campaign in Normandy. See RG243, E36, B191, General Omar N. Bradley and Air Effects Committee, 12th Army, *Effect of Air Power on Military Operations: Western Europe*, 15 July 1945, 1.

²² Spaatz Box 202, HQ MAAF, “Appreciation of Air Attack against Enemy Communications and Supply in Italy,” 28 April 1944, 1-2. Tedder was also heartened by reports from the interrogation of German prisoners in Italy that attacks on marshalling yards there were playing havoc with rail movements. See AIR 37/1052, Memo, Tedder to Air Commodore Woolley, 16 February 1944, in which Tedder thanked Woolley for providing an extract from a POW’s diary. The soldier’s unit, it said, took nine days to move from Opicina in northern Italy to Rome, a distance of 325 miles, averaging 36 miles a day. This included detraining at one point, loading all troops and supplies into trucks, driving 80 miles to a point at which rail travel was possible again, and reloading everything on another train. Tedder closed his memo by saying “I find a certain amount of persuasion necessary in this country on the question of attacking railways. Your note has proved excellent grist to my mill.” The diary extracts are located in AIR 37/1052, MAAF PW Report, 9 February 1944.

definite and serious fuel and truck shortages. He recommended that the Allies continue attacks on marshalling yards and key bridges to force the Germans to use more gas and wear out more trucks. To make his case, this source also quoted a German General Staff officer as having said, on 15 November 1943, that "If the bombings of our communications had continued as in September and October, we would have had to withdraw to a line north of Rome."²³ Unfortunately, Allied bombers did not continue these attacks, instead moving to other areas, and the Germans were able to make the necessary repairs. This argued in favor of concerted attacks on specific transportation zones rather than dispersed attacks against the entire railroad infrastructure. Here, too, Zuckerman saw improvements they needed to make for the transportation campaign in support of Overlord, including concerted attacks on rail centers around Paris and those between Paris and Normandy.

Zuckerman's association with Signor Caliendo, chief engineer of the Italian Ministry of Communications, also yielded insights for planning transportation attacks in France. Caliendo said "The heavy bombardment of important railway targets has a more consistent and lasting effect" than attacks on rail lines. Destruction of locomotive repair shops, signaling and switching apparatus, roundhouses, and communications gear at rail centers had a major and long-term impact on Italian railroads. Caliendo said the 18 April 1943 raid on Palermo's marshalling yards had caused severe damage, as had the 19 July 1943 and 7 March 1944 attacks on those in Rome. Through lines were repaired within days, but marshalling operations were seriously disrupted, leading to long delays in the assembly and movement of trains. He suggested that concerted attacks followed by

²³ Spaatz Box 114, CSDIC, "Interrogation of high-ranking Italian officer," 8 January 1944, 1-2.

frequent reconnaissance missions would allow the Allies to assess damage, track the progress of repairs, and schedule repeat attacks. Finally, he said there was a synergy between heavy bombers, which were best suited for attacks on rail centers; medium bombers, which were ideal for attacking bridges and viaducts; and fighter-bombers, whose strafing of truck convoys made distribution of supplies at the front dangerous and time-consuming. These ideas proved remarkably prescient, and although they did not make it into a formal report until July 1944, Zuckerman and his Bombing Survey Unit had long since recognized their utility.²⁴

What Zuckerman and Tedder glimpsed in these various BDA reports, interrogations, and discussions was a case of “cascading effects” in which attacks on marshalling yards pushed railheads back (a first-order effect) and forced the Germans to demotorize their divisions and use their trucks as supply-haulers (second-order effects). The strain this placed on their trucks, and the huge quantities of gasoline they used during these supply runs, had the ironic effect of exacerbating truck and fuel shortages (third-order effects). The high loss rate for trucks driven at night, over bad roads, and nonetheless attacked with some regularity by night-bombers, further strained truck and supply shortages as the cargo being carried was often destroyed along with the truck (fourth-order effects). In addition, attacks on road and rail bridges, which by early 1944 were becoming quite effective, delayed the arrival of supplies and reinforcements by days or even weeks (fifth-order effects). Finally, although the Germans received just enough supplies to wage a static defensive battle, resistance collapsed as soon as an Allied breakthrough forced

²⁴ RG243, E36, B176, 361-7368, “Observation and Opinions on the Allied Bombing of the Italian Railway System,” Prepared by Engineer Caliendo, Chief Engineer of the Italian Ministry of Communications, July 1944.

them into maneuver warfare, which they lacked the fuel to engage in for more than a few days. The combat power of the German army was thus compromised by constant and severe supply shortages (sixth-order effects).²⁵ Fortunately for the Germans, they were defending a narrow peninsula ideally suited to defensive operations. They would not be so lucky in France.

In addition to these insights about how best to starve an army of supplies, Zuckerman and Tedder learned a great deal about the pitfalls associated with transportation attacks, including German countermeasures and repair capabilities. Once again, an Italian officer provided useful insights. He noted that Allied bombers had devastated the huge Bologna marshalling yard, but that the Germans had built several loop lines around the city. He recommended attacking a few rail junctions outside the city to stop traffic entirely. He also noted that concerted attacks against precise geographic zones rather than attacks all over the country would pay greater dividends. Zuckerman and Tedder took these comments to heart but ignored this officer's assertion that attacks on bridges were highly effective in delaying the movement of supplies.²⁶

²⁵ As will become clear in this chapter, the concept of cascading effects was clearly present in the conceptualization, planning, execution, and damage-assessment processes for both the transportation campaigns and the oil campaign. General Spaatz and Air Commodore Sidney Bufton, for instance, both saw very clearly that a concerted attack on German oil production would create a whole series of effects that would degrade the combat power of the German army and the Luftwaffe at the fighting fronts. The term "cascading effects" itself, however, is much newer. Its military usage dates to the early 1990s, when a number of theoretical writings and doctrine documents began incorporating the term as part of a larger discussion of effects-based operations (EBO). Some of the more notable examples are "Dominant Effects: Effects-Based and Joint Operations," *Aerospace Power Journal*, Fall 2001; "Complexity-Based Targeting: New Sciences Provide Effects," *Air & Space Power Journal*, Spring 2003; Joint Publication 3-56.1, *Command and Control for Joint Air Operations*, 14 November 1994; and Joint Publication 3-60, *Joint Doctrine for Targeting*, 17 January 2002. What a number of the authors who produced these and similar documents seem to have missed is just how aware Allied air intelligence officers were of this concept by 1944. I have chosen to use "cascading effects" as a conceptual and an organizational tool for discussing the effects and effectiveness of Allied bombing campaigns even though the term itself is relatively new.

²⁶ Spaatz Box 114, CSDIC, "Interrogation of high-ranking Italian officer," 8 January 1944, 3-4.

In contrast to their British counterparts, Spaatz and his subordinates followed bridge attacks carefully and were impressed by the amount of time it took German combat engineers to rebuild damaged bridges. The Germans spent an average of 17 days completing these repairs. It took them up to a month to repair longer bridges, especially those constructed of steel girders. This included a period of two days to assess the damage and then to assemble repair crews and materials at the bridge. Several additional hours had to be spent disposing of anti-personnel "butterfly bombs" which exploded with varying delays and thus had to be destroyed one at a time, with aimed rifle fire. The end result was a serious delay in railroad shipments.²⁷

Spaatz also profited from a series of 15th Air Force ORS reports on the accuracy of bomber attacks on bridge targets. The culminating report noted that 706 bombers dropped 1,906 tons of bombs on bridge targets during the period from 1 April to 4 June 1944. Their accuracy in good weather was 41 percent of bombs within 1,000 feet; in bad weather, 26 percent within 1,000 feet. Of 22 bridges attacked, seven received hits. It thus took an average of 101 bombers dropping 270 tons of bombs for each hit. This was a major improvement over the same period in 1943, when it took an average of 190 bombers to produce one hit. The report's key recommendation to improve accuracy was to bomb on as many independent sightings as possible from three-ship formations instead of the six or nine aircraft frontage in combat box formations. This was the exception to the rule that LeMay's lead-bombardier technique was more accurate. Bridges had very easily recognizable aimpoints that allowed even inexperienced bombardiers to lay the

²⁷ Spaatz Box 18, 15th Air Force, "The Repair of Railroad Bridges by the German Army," 5 May 1944, 1-4 and Appendix; Eaker B I:30, F6, HQ MAAF, "Allied Strategic bombing," Interrogation of Major Gallenkamp, a German intelligence officer, 11 June 1945, 1.

Norden bombsight's crosshairs on target. Other recommendations included attacking bridges only in good weather and going after the longest bridges, which were easier to hit and harder to repair, especially if a bridge had more than a 100-foot span.²⁸

The most striking thing about Zuckerman's and Spaatz's differing views on the importance of marshalling yards and bridges is that each convinced Eisenhower to back his plan. While the Zuckerman-Tedder plan became the official pre-Overlord transportation campaign, Ike also gave Spaatz permission to use his bombers to go after bridges and oil targets.²⁹ The result was an unlooked-for but nonetheless vital synergy in which simultaneous attacks on marshalling yards, bridges, and oil resulted in an insurmountable series of logistical, operational, and strategic crises for the German armed forces. By the time the Normandy campaign entered its second month, there was no mistaking how effectively the three interacted. The increasingly severe fuel shortages brought on by the oil offensive also led to a gradual shift in July-August 1944 from a crisis in the *distribution* of fuel to one involving *both supply and distribution*.

²⁸ Spaatz Box 18, 15th Air Force ORS, "Fifteenth Air Force Attacks against Bridges 1 April 1944 to 4 June 1944," 7 June 1944, 1-5. This report was published the day after Overlord, but Spaatz had been seeing earlier reports for the past several months and had a firm notion that bridge attacks would be lucrative in France, as in fact they were.

²⁹ Dr. B. G. Hopper, the USSTAF historian, produced a draft paper on this contentious issue, confirming that Eisenhower gave his official approval to the Tedder-Zuckerman plan but also gave informal approval to the Spaatz plan. Hopper noted that "Washington and Whitehall were reluctant to sit in judgment. In the end, the whole matter was put up to General Eisenhower. His solution was to attempt to strike a crude balance between the two...During the five months they [Allied heavy bombers] were under Eisenhower the campaign for German oil was fought without benefit or let of a formal military directive...The battle was opened on the Supreme Commander's nod to Spaatz." See Spaatz Box 202, Draft History of the Oil-versus-Transportation Debate (no title), and Cover memo from Colonel Maxwell to Dr. B. G. Hopper, Historical Section, HQ USSTAF, 2 November 1944, 21. Just how contentious and politically sensitive the issue was is clear in the cover memo Colonel Alfred Maxwell, the USSTAF Director of Operations, wrote to Hopper when he returned the draft paper to him. He said: "The attached draft is forwarded for your personal files as an example of a very contentious, controversial matter, so that you will know how to recognize same and thereby be better prepared to comply with the letter of your recent directive. After you have finished same, I recommend that it be sealed in a time capsule or merely consigned to an average, everyday, military file. In either case, it will probably be safe from the light of day for the next five thousand years."

Tedder and Zuckerman sent their insights from Italy to the Transportation Intelligence Committee (TIC), to assist with discussion of the best means for isolating German units in Normandy. This group was comprised of every civilian and military expert on railroads, including the chairman, C. E. R. Sherrington of the Railroad Research Service (RRS), who chaired these meetings; Squadron Leader W. Wigglesworth of A.I.3(e) (the Air Ministry's BDA office); several RAF and USAAF officers from A.I.3(c) (the Air Ministry's targeting office); several more from the ACIU, including F (Transportation) Section; and a number of others from the major ground commands slated to spearhead the invasion. These same players would soon comprise the Transportation Targets Committee (TTC), which made target recommendations to Eisenhower, Tedder, and Air Chief Marshall Sir Trafford Leigh-Mallory, commander of the Allied Expeditionary Air Forces (AEAF), before and during Overlord. The TIC's first order of business was to obtain reports on key rail centers in France, Belgium, and western Germany from the ACIU's F (Transportation) Section. Major Moody of F Section produced a series of detailed interpretation reports, based on the latest reconnaissance cover, for every one of the 73 marshalling yards then on the target list. A.I.3(c) used these reports to prepare target dossiers.³⁰

In January 1944, Squadron Leader Wigglesworth sent ADI(Ph) a request for reconnaissance cover of the 15 marshalling yards for which the TIC did not yet have adequate photographs. He reminded ADI(Ph) that the request originated with the RRS, whose "position in relation to the Service Ministries was fixed before the war by the

³⁰ AIR 40/1171, "Minutes of Transportation Intelligence Meeting No. 143 held at 4, Cowley Street, S.W.1 on 7th October 1943," 1-3; AIR 40/1171, Memo, AI3(e) to ADI(Ph), "Railway Reports," 14 October 1943; AIR 40/1171, Memo, AI3(e) to ADI(Ph), "Railway Reports Series FS," 15 October 1943.

Committee of Imperial Defence. It was then arranged that they should be regarded as expert advisors on railway matters to all Service Ministries and to the Ministry of Economic Warfare.”³¹ This was particularly significant in view of Sherrington’s dual position as head of the RRS and a senior member of MEW, the only person to occupy two such positions simultaneously. Wigglesworth’s request marked the point at which target materials development and detailed operational planning began.

On 22 January 1944, a paper written by the Air Ministry’s Director of Bombing Operations, Air Commodore Sidney Bufton, went out to all senior operations and intelligence personnel involved in planning the transportation campaign. It became the blueprint for a campaign encompassing concerted and systematic attacks on key marshalling yards in France, Belgium, the Netherlands, Luxembourg, and western Germany from March to October 1944. The document went out under Bufton’s signature, but it had Zuckerman’s and Tedder’s fingerprints all over it, along with those of Sherrington and other RRS experts. The point of departure was the paper’s assertion that “Although line capacity is plentiful, motive power is short.”³² Since 1942, the Germans had commandeered 4,000 of 12,000 locomotives belonging to the French National Railroad (the *Société National des Chemins du Fer*, or SNCF) for use in Germany and in the East. Most were heavy locomotives for pulling large trains and represented a disproportionate loss of motive power. The RRS assessed that the SNCF was carrying as much as it could and would be unable to expand its operations even after D-Day due to a shortage of locomotives.

³¹ AIR 40/2069, AI3(e) to ADI(Ph), “Request for Photographs of Railway Centres,” 25 January 1944.

³² AIR 37/552, Allied Expeditionary Air Forces (AEAF), Air Plans, “Operation ‘Overlord’: Delay and Disorganization of Enemy Movement by Rail,” 22 January 1944, 1-2.

Zuckerman's influence became clear in an ensuing summary of the offensive against Italy's railroads, which noted that concerted bombing of six rail centers in Sicily and southern Italy

virtually brought the railway system to a standstill through the destruction or isolation of servicing and repair facilities, rolling stock and tracks (with the consequent blocking of yards), the dislocation of signaling and switch systems, the interruption of water and electrical supplies... The paralysis so caused was not a result of the cutting of lines, nor was it determined by the geographical lay-out of the system: essentially it was the result of widespread damage affecting every element of the railway centres attacked, and particularly of the destruction of rolling stock and servicing facilities, and of the choking of marshalling yards.³³

The most the Germans could do, the paper continued, was to open one or two through lines within a week of the attacks. By the end of the Sicilian campaign, the railhead was *north* of Naples. An RRS note in the paper said the BDA lessons of the Italian campaign indicated that reducing traffic flow was the key factor: "if the enemy were deprived of the use of locomotives in a given area, and if in addition he were also deprived of the ability to use locomotives transferred from elsewhere, railway movement within the area would come to a standstill."³⁴

In another argument imported directly from Zuckerman's analyses, the paper emphasized that the destruction of major repair facilities was essential to reducing locomotive serviceability. The requirement for both routine and major maintenance, all of which occurred at marshalling yards, meant that nearly 40 percent of available locomotives would be at these key installations at any given time and thus liable to attack and destruction. And where there were locomotives there was also rolling stock. Finally,

³³ Ibid., 3.

³⁴ Ibid., 4.

the signaling systems, track-crossing controls, and through lines vital to efficient operations were at the rail centers. Destruction of these items at several adjacent rail centers would thus make movement within an entire region nearly impossible.³⁵

To make matters worse for the Germans, they were not in a position to return very many of the locomotives looted from France in previous years because they were fully employed in the Reich or on the Eastern Front. In addition, not only was there no spare track in France, but the Germans had already removed several hundred miles of tracks and crossings for use on the Eastern Front, meaning that every foot of track destroyed would require a sacrifice of track from some other part of the existing railroad network. Finally, coal shortages and the lack of heavy repair equipment—especially cranes capable of lifting locomotives, of which there at most 20 in all of France—would also be exacerbated by concerted attacks on marshalling yards, as would the shortage of skilled railway workers, many of whom would become casualties, absent themselves, or join the Maquis during the bombing campaign. Therefore, the report noted,

Every succeeding attack would add to the difficulty of effecting repairs. Disorganisation and stagnation would be cumulative, and before the full programme of attacks...was completed, the enemy's repair organization would be completely overwhelmed. The Railway Research Service are confident that repairs within any period of tactical relevance would then be impossible, and that when all the centres had been dealt with the traffic in the area would be virtually at a standstill. The Railway Research Service also state that under these conditions the enemy would take at least a week and possibly more to move three or four divisions from East of the Pas de Calais area to west of Paris by rail.³⁶

The 34 French and Belgian marshalling yards selected by the RRS as the most important for attack were good targets from a bombardier's perspective because they

³⁵ Ibid., 4-5.

³⁶ Ibid., 7.

were large and easy to locate. In addition, four of the 34 were on electrical lines running from Paris to Bordeaux and Lamont. Destroying these four installations and the power stations associated with them would require the diversion of 500-900 steam locomotives to make good the losses. Attacking another 39 German marshalling yards near the French border and therefore within range of Oboe and Gee would enhance the effects of these attacks. Finally, RRS analysts said sabotage by SAS and Maquis teams could be effective given the disorganization caused by invasion and bombing.³⁷

The fact that the RRS proved correct on all counts was a testament not only to their high degree of expertise in such matters but also to the Allied ability to incorporate BDA-related insights gathered in previous bombing campaigns into their plans for future ones. Put simply, Zuckerman's reports on the bombing of Italian marshalling yards had a huge influence on the planning and execution of the transportation offensive against the railroads in France. This was most evident in the report's conclusions, which stated that cutting rail lines would not work, and that "careful reconnaissance" would be required to determine the effects and effectiveness of attacks on the French railroad network. The experience in Sicily and southern Italy, along with RRS opinion, made clear the efficacy of bombing marshalling yards to isolate German troops from supplies and reinforcements. Also conspicuous by its absence was any mention of bridge attacks, which Zuckerman believed to be a waste of time but which, in conjunction with attacks on rail centers, came to play a vital role in the bombing campaign.³⁸

³⁷ Ibid., 8-10.

³⁸ Ibid., 11.

Just before the release of this crucial report, Air Vice Marshal H. E. P.

Wigglesworth, Senior Air Staff Officer of the AEA, directed the formation of the AEA Bombing Committee, which was charged with determining the suitability of targets for bombing, reconciling bombing commitments with available effort, allocating priorities to all targets, and apportioning bomber effort to targets.³⁹ During the next month, the committee met 10 times to address these issues. Significantly, both Zuckerman and Colonel Richard Hughes, head of the USSTAF Target Section and one of the Allies' foremost targeting experts, were present at nearly every meeting, and the later venues were chaired by Leigh-Mallory himself, who clearly recognized their importance.⁴⁰ A key decision taken by the committee was to bomb from 14,000 feet (instead of the usual 22,000-23,000) given the light defenses around French rail centers. Also crucial was the decision to expand the number of Gee- and Oboe-equipped aircraft in Bomber Command and 8th Air Force, which, combined with the lower bombing altitudes, resulted in mean points of impact within 150 yards of the aimpoint, a devastatingly effective capability.⁴¹

³⁹ Note that there were two Wigglesworths involved in targeting and BDA efforts: Air Vice Marshal Wigglesworth and Squadron Leader W. Wigglesworth of A.I.3(e) (the Air Ministry BDA office), mentioned earlier in this chapter.

⁴⁰ Dr. B. G. Hopper, the USSTAF Historian, noted that Hughes, who had been born an Englishman but emigrated to the United States and became an American citizen, headed up General Spaatz's targeting team. "The American technical team," Hopper said, "was comprised of a group of airmen-economists led by Colonel Richard D. Hughes, an Englishman-turned-American. He was one of the very first air intelligence officers in the Air Corps and helped draft AWP-1. He became General Spaatz's targeting expert along with his staff of young civilian economists and technicians, whom he referred to collectively as his 'long-haired boys.' Hughes was, according to Hopper, 'esteemed for his independent and penetrating mind, and the high standards he applies to military intelligence.'" See Spaatz Box 202, Draft History of the Oil-versus-Transportation Debate (no title), and Cover memo from Colonel Maxwell to Dr. B. G. Hopper, Historical Section, HQ USSTAF, 2 November 1944, 3-4.

⁴¹ AIR 37/512, "A.E.A.F. Bombing Committee," 12 January 1944; AIR 37/512, "Notes on the Third Meeting of the Allied Air Force Bombing Committee...on 13 January 1944"; AIR 37/512, "Notes on the Fourth Meeting of the Allied Air Force Bombing Committee...on 14 January to Discuss Radio Aids for Heavy Bomber Operations."

Despite an emerging consensus in the AEF Bombing Committee on the operational requirements for the transportation campaign, there were also disagreements among senior Allied air and ground commanders as to the most effective use heavy bombers in support of Overlord. The arguments revolved around the two competing plans put forth by Zuckerman and Tedder, on the one hand, and Spaatz on the other. Spaatz's plan called for an all-out attack on German oil production to immobilize the Reich's armies and air forces in the field, and attacks on bridges over the Seine and Loire Rivers to delay German troop and supply movements to Normandy. Spaatz said his support for the oil option did *not* imply that attacks on transportation assets should not play a strong part in isolating the battle area, and he emphasized that bridge attacks would address this issue. He then noted that Germany's 14 largest synthetic oil plants comprised 80 percent of all her synthetic oil and fuel production. His plan called for attacks on these and the 13 largest crude oil refineries, which accounted for 60 percent of refining capacity. Spaatz argued that transportation attacks would not affect course of the initial battle but oil attacks would; that attacks on transportation would not bring out the Luftwaffe in force, but that "they will defend oil to their last fighter plane"; and that oil attacks would weaken the German army and Luftwaffe *on all fronts simultaneously, including the all-important Eastern front.*⁴² Spaatz was wrong on the first point but absolutely on the mark

⁴² AIR 37/1125 and Spaatz Box 114, "Employment of Strategic Air Forces in the Support of Overlord," 24 March 1944, 1-3. Emphasis added. To drive home his point about the importance of attacking oil, Spaatz included as an Appendix to his proposal the Wehrmacht's BASIC ORDER NO. 24, "Order from Quartermaster General of the Army, dated General Headquarters of High Command of Army, 13th December, 1943, Measures to economise motor fuel." It said: "Motor fuel is a means of movement. At a decisive hour, we will not be able to move either our tanks or our fast units if there is no motor fuel. The motor fuel situation is serious. In 1944, it may become still more serious. Restrictions have to be imposed in January. It is impossible to give more than there is. A crisis with motor fuel, such as we have experienced with the light field howitzer ammunition, must be avoided in time. The Order of the Hour for motor fuel, therefore, is: **ECONOMIZE NOW WHENEVER POSSIBLE.**"

with the other two. His assertion that oil attacks would erode and eventually undermine the maneuver ability and combat power of the German armies and air forces in the field also put to flight any allegations, then or now, that he was an airpower "zealot" who felt heavy bombers could win the war on their own. Indeed, in this instance and several others, Spaatz proved himself, along with Tedder, to be an advocate of combined-arms warfare in which bombers facilitated a much more rapid and less costly victory for Allied armies. As we shall see in the following chapter, this was nowhere more true than on the Eastern Front, where the oil offensive had its greatest operational impacts.

Spaatz also noted that the JIC, MEW, and Air Commodore Bufton had all recommended against the Tedder-Zuckerman plan.⁴³ Bufton, in fact, sent Portal a note explaining why he favored Spaatz's plan. "The American Air Staff," he said,

appreciate, and M.E.W. agree, that it is within the capabilities of the combined bomber forces to effect such a reduction in German oil supplies as to reduce considerably the mobility of the enemy's armed forces on all fronts and to cause a spreading crisis throughout his economy. Reduction of military oil allocations on this scale would gravely impair the mobility of the German Armed Forces on all fronts. In these circumstances, the enemy could only maintain allocations to the forces confronting "OVERLORD" at the expense of such a severe curtailment of supplies to his forces in the East that he would be courting a major break-through by the Russian Armies, involving heavy losses in troops and equipment and the probability that the Balkans would be overrun.⁴⁴

⁴³ See Spaatz Box 114 for an MEW study, provided as an addendum to Spaatz's plan, which provided support for Spaatz's plan, stating that it would cause a 40 percent drop in fuel and oil production during the first six months of Allied bombing. This equaled 2.1 million tons of lost production, leaving the Germans only 3.5 million tons—far too little to sustain combat operations at the required levels.

⁴⁴ Spaatz Box 114, Draft Paper, Bufton to Portal, "Note on the Employment of the Strategic Bomber Forces Prior to Overlord," 19 March 1944, 3-4. Spaatz's Deputy Director of Operations, Colonel Alfred R. Maxwell, also emphasized the importance of oil to the German effort on *all* the fighting fronts. See Spaatz Box 114, "Comments on Paper DAC/MS.100., Subject, 'Employment of Allied Air Forces in Support of Overlord,'" Col Maxwell, no date, but probably fall 1944), 2, in which Maxwell said, "Actually, the USSTAF oil plan was based on an even higher level of argument than this: the mission of the strategic air forces should be considered from the viewpoint of the war as a whole; on all European fronts and until the very last day of fighting. In this concept, oil was the most decisive system available, which would achieve considerable shortening of the war and the saving of many lives."

Buften, a longtime advocate of both oil attacks and "precision" bombing, was clearly on Spaatz's side in this argument, and would continue to be so. In echoing Spaatz's assertion that oil attacks would have a major operational impact on the Eastern Front, Buften, too, proved prescient.⁴⁵

Spaatz was mistaken, however, in asserting that attacks on marshalling yards against Sicily and southern Italy had failed. He simply overlooked the vital importance of employing airpower in a concerted fashion against these key facilities. His criticisms implied that anything short of a complete collapse of enemy resistance as the result of attacks on rail centers equaled failure. This was unrealistic and missed the point that such attacks, even if not capable of producing decisive results *on their own*, would nonetheless cause widespread friction and degrade the enemy's fighting ability, in the process providing a major force-multiplier for Allied ground armies. He also erred badly in stating that the enemy had "a large surplus beyond his military requirements" of marshalling yards, locomotives, and railcars.⁴⁶

The essentials of the Zuckerman-Tedder plan included concerted attacks on key marshalling yards in France, Belgium, and western Germany. The aim was to degrade and disrupt railroad networks severely enough to make the movement of German troops and supplies to Normandy slow and costly. Although Zuckerman and Tedder admitted

⁴⁵ It is important to remember that the vast majority of German divisions were on the Eastern Front. See MS16, S5, B12, F4, "Commanders Weekly Intelligence Review No. 4," HQ SHAEF, 30 April 1944, which reported that of 344 German divisions in the field, 205 (59.5 percent) were on the Eastern Front, including 37 (64.9 percent) of the 57 Panzer and Panzer Grenadier divisions. The totals in the West were 56 divisions (16.3 percent) and eight Panzer and Panzer Grenadier divisions (14.0 percent). Note that two-thirds of the Panzer and Panzer Grenadier divisions were stationed in the East. This makes particularly clear how susceptible German operations in the East would be to the major fuel shortages brought on by the oil offensive from late summer 1944 to VE Day.

⁴⁶ Ibid., 2.

that a complete stoppage of rail traffic was impossible, they argued that bombing could reduce it to a trickle. They also said

No one can question that the Oil Plan, in view of the proved ability of the U.S. Strategic Air Forces to carry out precision attacks deep in Germany, would ultimately have grave effects on the whole German war effort. It is difficult, however, to see evidence to support the view that it could be expected to take real effect in time for Overlord or the land operations following the assault.⁴⁷

They proved entirely correct on the first two points but incorrect on the third. The oil offensive would have grave effects on German operations in Normandy, but not until well *after* D-Day. What Zuckerman and Tedder failed to anticipate was the length of the Normandy campaign. By the time Allied armies made their breakout in early August 1944, the Germans were plagued by fuel shortages that were no longer due simply to distribution problems. The oil offensive was beginning to run them out of gasoline. Nonetheless, the Zuckerman-Tedder transportation plan proved correct in its most basic question: Concerted bombing of key marshalling yards could and did create an insuperable logistical and operational crisis for German armies in Normandy.

Eisenhower made his decision at a meeting of top commanders on 25 March 1944. He said everything he had read convinced him that apart from the continuing attack on the Luftwaffe and its sources of supply, only the transportation plan would allow the air forces to make important contributions to the land battle during the first weeks of Overlord. Nonetheless, Ike in effect approved both plans by giving Spaatz the go-ahead to attack oil and bridge targets even as he publicly supported the Zuckerman-Tedder plan to attack rail centers. Because the Allies had enough aircraft, all three target sets received

⁴⁷ Spaatz Box 114, "Employment of Allied Air Forces in Support of 'Overlord,'" 24 March 1944, 2-3.

concerted attacks, and the synergy they produced yielded results *far greater* than any that could have been achieved attacking just one or two.⁴⁸

Two days earlier, Tedder had formed the Transportation Targets Committee (TTC, later changed to the Railway Targets Committee, or RTC) to assist him with the direction and control of attacks on French railways. The committee included most of the members of the recently-disbanded Transportation Intelligence Committee, including Zuckerman and Hughes. The TTC employed the myriad of BDA reports produced during the transportation offensive to assess damage to each target, update its weekly target-priority list, request reconnaissance sorties to provide the most complete BDA picture, and issue reports on the progress of the campaign. The BDA reports referred to in determining damage levels and target priorities included strike photos and strike-attack reports with bomb plots from bombardment units, 1st-phase (Immediate) and 2nd-phase Interpretation Reports from ACIU K and F Sections, and 3rd-phase reports from MEW and the RRS.⁴⁹

The result of the TTC's efforts was a comprehensive target list that included rail centers and bridges but overlooked canals as means of transportation. An Office of Special Services (OSS) report pushed for attacks on canals. The OSS provided detailed information on canal locks outside of French towns and closed with a note that the Maquis was already sabotaging canal locks in France, and that large contingents of the Germans' Todt Organization were constantly at work repairing them. These were recommendations senior airmen should have heeded. The fact that a copy of the report is

⁴⁸ AIR 37/1116, Minutes, "Final Minutes of a Meeting Held on Saturday, March 25th to Discuss the Bombing Policy in the Period before OVERLORD," 25 March 1944; AIR 37/1116, SHAEF, "Directive by the Supreme Commander to U.S.S.T.A.F. and Bomber Command for Support of OVERLORD during the Preparatory Period," 17 April 1944, 1.

⁴⁹ AIR 37/1116, SHAEF, Directive, "Direction of Operations of Allied Air Forces against Transportation Targets," 15 April 1944.

currently in General Spaatz's files underscores the fact that he and his staff had read it. They should have planned accordingly but instead had to rely on SAS reports, produced over a month *after* the D-Day, before they recognized that the Germans were using canals to transport supplies and entire divisions into Normandy, albeit slowly. Only after they received these reports did airmen steer their bombers towards canals.⁵⁰

As Allied leaders argued over the plan and its timing, Portal had already directed Harris to begin a series of attacks on French rail centers in early March 1944. The raids were designed to confirm the effectiveness of Gee- and Oboe-guided attacks on these targets and to force Harris to employ his bombers in support of preparations for Overlord rather than exclusively on city-attacks. Harris resisted mightily but by March had agreed grudgingly to go after rail centers—another “panacea target” in his book.⁵¹ His target list encompassed 12 of the most vital marshalling yards, including the huge one at Trappes, outside of Paris, which was the first to feel the fury of Bomber Command's attacks.⁵²

9.3 Applying Lessons Learned: Transportation Attacks and Overlord

The opening attack on Trappes on the night of 6-7 March involved 261 Halifax heavy bombers and six Pathfinder Force Mosquitoes. The first K report noted extremely

⁵⁰ Spaatz Box 187, OSS, Report No. SQ-706, “France-Germany: Economic, Canal System,” 10 February 1944.

⁵¹ See AIR 37/752, Memo, Harris to Leigh-Mallory, and report entitled “The Employment of the Night Bomber Force in Connection with the Invasion of the Continent from the U.K.,” 13 January 1944, 1-8. Harris argued that the heavy bomber force was unsuitable for attacking marshalling yards and could by no means be used in daylight attacks against these or any other targets. “It is thus clear,” he concluded, “that the best and indeed the only efficient support which Bomber Command can give to OVERLORD is the intensification of attacks on suitable industrial centres in Germany as and when the opportunity offers.” Leigh-Mallory's staff and Portal's worked together to produce a very effective rebuttal of every one of Harris's arguments. In the end, Harris was wrong on all counts. His bombers attacked marshalling yards with devastating accuracy, and they soon began flying day raids against marshalling yards and oil targets with light casualties. See AIR 37/752, a table constructed by AEAf and Air Ministry officers refuting each of Harris's arguments, 27 January 1944.

⁵² AIR 37/513, “Attacks on Enemy Rail Communications in Connection with Operation ‘Overlord,’” 2 March 1944.

heavy damage with over 190 direct hits on the through tracks, which cut the main electrified line between Paris and Chartres as well as all other through lines. At least 50 of these bombs also fell directly on rolling stock, destroying or severely damaging several hundred wagons. A supplemental K report noted that the locomotive shed was 75 percent destroyed, the station's water tower destroyed, and at least six locomotives wrecked. The following night, 304 heavy bombers did serious damage to the Le Mans marshalling yard, destroying 250 wagons, a roundabout, and six locomotives. Every through line was also cut. A Railroad Targets Committee (RTC) damage assessment noted that a second raid on Le Mans by 205 heavies six nights later did even more severe damage. The locomotive and wagon repair shops as well as the engine sheds were either severely damaged or destroyed. Over 800 wagons and 15 locomotives were also wrecked. Reconnaissance cover of 17 March showed only one locomotive with steam up and very little other activity, indicating severe damage was done. These opening raids continued on 15-16 March and 17-18 March with two attacks on the Amiens-Longreau marshalling yard, causing such severe damage that it took 27 days of repairs to restore basic marshalling capabilities.⁵³

⁵³ The reports for Trappes are in RG243, E27, B157, Target Damage File, Trappes Marshalling Yard, ACIU K Section, "Immediate Interpretation Report No. K.1916, 8 March 1944; ACIU K Section, "Supplement to Immediate Interpretation Report No. K.1916, 11 March 1944. For the other attacks, see AIR 37/1052, Railway Targets Committee (RTC), "Railway Centres: Summary of Operations and Intelligence 9 February to 22 March, 1944" (Summary No. 1), 23 March 1944. This initial RTC damage assessment relied heavily on K Section reports and also provided a methodology for gauging the effectiveness of each attack in which each marshalling yard was assigned a letter-based rating. An "A" rating, which Amiens/Longreau received, meant that the marshalling yard was damaged to such an extent that no future strategic attacks required. Category "B" meant severe damage, but some vital installations intact. Category "C" meant the installation had been attacked, but little or no material damage done. Category "D" indicated a marshalling yard was authorized for attack but not yet hit, and Category "E" meant it was scheduled in the plan, but not yet authorized for attack. The latter two categories remind us that attacking French and Belgian targets was a very touchy issue due to the casualties caused to Allied civilians by such attacks. Because of this, Churchill and Roosevelt had to approve each target for attack.

The RTC damage assessments evolved rapidly as the transportation campaign progressed. Summary No. 2, produced for raids carried out 23-30 March, and all subsequent summaries were divided into three parts: Attacks, Damage and Repair, and Deductions. The most effective attack that week was made against Creil, where every structure was flattened and 21 locomotives destroyed as well as large quantities of rolling stock. No effort at repair was visible three days later, and subsequent reconnaissance photos confirmed that the French and Germans simply abandoned Creil. Reconnaissance cover obtained during this period showed that at Trappes, 17 days of repairs were required before even the most basic marshalling activities could resume. Even more important, most of the locomotives were still immobilized inside the damaged engine sheds or on sidings yet to be repaired. In Part III, the report provided three crucial assessments about the effects and effectiveness of bomber attacks against marshalling yards. The first was a recognition that even a highly successful attack would usually prevent through traffic for no more than three days. The second was that a successful attack might stop marshalling activity for twelve or more days. The third insight, based on ACIU F reports and reconnaissance cover of damaged marshalling yards, was that the enemy made repairs in the following order: to through routes, to traffic-sorting areas, and to facilities for maintenance of rolling stock. At this point, locomotive repair shops had lower priority, which soon caused the Germans severe difficulties as the number of damaged and destroyed engines skyrocketed after D-Day, particularly once fighter-bombers started to strafe moving trains. Because the Bomber Command attacks began a month before Eisenhower issued his bombing directive, they gave BDA experts an

opportunity to determine how the Germans would respond to Allied attacks, and where their key weaknesses were. These first attacks thus paid huge dividends for BDA.⁵⁴

A period of bad weather halted attacks for the following week, but raids commenced once again on 9-10 April with an attack on Lille by 239 aircraft that destroyed a locomotive shed, a locomotive repair shop, and most of the wagon repair facilities. According to French records obtained after the liberation of Lille, 2,124 of the 2,959 wagons in the yard were destroyed. Several locomotives were either destroyed or damaged. While the other 14 attacks carried out during the following four days were less successful, most resulted in moderate or light damage and destroyed a number of wagons and locomotives. The rate of destruction, particularly with respect to wagons and engine repair facilities, far outpaced the rate of repairs. Reconnaissance cover also confirmed that the locomotive repair depots formerly at Amiens and Creil had been transferred to Crepy-en-Valois, Compiègne, and Le Bourget, which soon led to attacks on those installations. Very little escaped the notice of ACIU photointerpreters by this point.⁵⁵

Attacks the following week, 14-20 April, were the first carried out under Eisenhower's bombing directive. Of the ten attacks, two caused severe (Category "A") damage, three caused moderate (Category "B") damage, and five missed their targets. Although a 50 percent miss rate was high even by 1944 standards, it is a reminder that Allied bombing, even of large targets like marshalling yards, was often inaccurate and frequently caused civilian casualties. Nonetheless, the two Category "A" attacks caused

⁵⁴ AIR 37/1052, RTC, "Operations against Railway Centers: Summary No. 2, March 23rd – 30th", 30 March 1944, 1-3. For further insights on Criel, see AIR 37/1052, RTC, "Operations against Railway Centers: Summary No. 6, April 20th – 26th", 27 April 1944, 2.

⁵⁵ AIR 37/1052, RTC, "Operations against Railway Centers: Summary No. 4, April 7th – 13th", 13 April 1944, 1-2.

severe damage to Charleroi/St. Martin and Juvisy. At Charleroi, on 18 April, one roundhouse was entirely destroyed and the other severely damaged. All other structures were heavily damaged, all through tracks cut, and a large number of wagons destroyed. At Juvisy, attacked 18-19 April, heavy bombers obliterated the transshipment and locomotive sheds, and destroyed a large number of locomotives and wagons. Reconnaissance cover of Amiens showed repair efforts continuing, but still no marshalling activity, which was a key indicator photointerpreters looked for to determine proper timing for follow-on attacks.⁵⁶

This growing catalogue of destruction soon encompassed all French rail centers. In addition, marshalling yards in western Germany came under attack, with Aachen and Hamm suffering severe damage from 11-12 and 22 April raids. Aachen did not resume operations for nearly two weeks, while Hamm never fully recovered. Fritz Knickenberg, Chief Inspector of the Hamm railway district, noted in his diary that the 22 April raid was the worst of the war, leaving 1,251 bomb craters in the facility. No trains arrived, left, or passed through for two days, and traffic was 8 percent of normal a week later. He said:

On a normal day we handled 7,000 to 10,000 trucks; 70 or 80 passenger trains went through in both directions in 24 hours. After the April raid we were glad to get 6 or 7 trains through after 5,000 men had been busy day and night for 48 hours. To return to anything like a timetable meant continuous work for 4 weeks.⁵⁷

The raid destroyed the engine shed, a control tower, and many wagons. Some of these, loaded with ammunition, caused huge secondary explosions and fires.⁵⁸

⁵⁶ AIR 37/1052, RTC, "Operations against Railway Centers: Summary No. 5, April 14th – 20th", 21 April 1944, 1-2.

⁵⁷ AIR 40/1558, SHAEF, "The Allied Air Offensive," Air Staff, 9 July 1945, 2.

⁵⁸ AIR 37/1052, RTC, "Operations against Railway Centers: Summary No. 6, April 20th – 26th", 27 April 1944, 1-5.

It quickly became obvious that Allied bombers were producing major *effects*. What was less clear was the *effectiveness* of the raids in terms of their stated objective: to interdict as completely as possible the movement of reinforcements and supplies into the Normandy battle area. In the press of events, people sometimes forgot Solly Zuckerman's caveat that a major campaign against the French railroads would not produce major effects for *several weeks*, and that it would *act synergistically* with medium bomber and fighter-bomber operations, as well as SAS and Maquis direct-action missions, once the invasion had taken place. Also problematic was the better-than-expected repair rate. Le Mans, one of the first marshalling yards bombed, was operating at nearly full capacity 39 days after it was attacked. Of course, the Allies had enough aircraft to go after targets like Le Mans repeatedly and in fact did so, but Allied military leaders were taken aback by the return to operational status of rail centers their BDA experts had originally written off as damaged beyond repair.⁵⁹

Despite these concerns, there was a wealth of intelligence indicating how severely these pre-Overlord attacks were impeding rail movements. An RRS report noted that in January there had already been 347 trains held up in French marshalling yards awaiting locomotives. Since each train had between 60 and 90 wagons, this meant there were between 21,000 and 31,500 wagons sitting idle. Once attacks began, idled trains

⁵⁹ AIR 37/1052, RTC, "Operations against Railway Centers: Summary No. 6, April 20th – 26th", 27 April 1944, 2. For Allied bomber strengths, see Spaatz Box 231, "Numbered Air Force Aircraft Status," which showed bomber strength for 8th and 15th Air Forces in August 1944 was 3,635. In addition, 9th Air Force had 735 medium bombers. Of these 4,370 aircraft, about 80 percent, or 3,500, were operational at any given time. Bomber Command had nearly 1,500 operational heavy bombers and another 400 Mosquitoes. The Allied total was therefore about 5,400 aircraft in August 1944. At the start of the transportation offensive in March 1944, the figure was about 4,500. See Harris, *Despatch on War Operations*, 150-152, and Denis Richards, *RAF Bomber Command in the Second World War: The Hardest Victory* (London: Penguin Books, 1994), 231.

increased in number as locomotives were wrecked. This made raids even more destructive as thousands of wagons were destroyed on sidings.⁶⁰

By now, the Intelligence Operations Section at SHAEF was producing BDA reports for individual rail centers, which showed increasingly severe and permanent damage. Along with ACIU K and F reports, these products were building blocks for 3rd-phase assessments produced by the RRS. They included a description of the marshalling yard and its key facilities, dates of attacks and tonnages dropped, and the results based on reconnaissance cover as well as ACIU K and F reports. Three critical components—locomotive repair facilities, marshalling facilities, and through lines—were each given an “Out of Action” percentage, and the rail center was then given a category “A,” “B,” or “C” damage rating. By late May, most had “A” or “B” ratings. In fact, while repair crews were able to fix through lines quickly, the damage to locomotive repair shops and marshalling facilities was increasingly severe, and the number of destroyed and damaged locomotives was skyrocketing. A SHAEF BDA report produced on 23 May assessed nearly half of locomotive shops to be 50-100 percent destroyed. With many repair depots out of commission, damaged engines often had to be written off rather than repaired.⁶¹

The Germans’ problems also increased once bridges came under concerted attack on 8 May. Most of the bridges over the Seine and Loire Rivers were down within the next two weeks, as were a large number over the Albert Canal, the Meuse, and most other

⁶⁰ AIR 37/719, Memo, RRS to Air Commodore McCloughry (AEAF), 20 March 1944.

⁶¹ For an example of these SHAEF BDA reports, see Spaatz Box 203, “Acheres, Bomb Damage Assessment No. 2, Recce. 9 May 1944,” which showed the locomotive depot 80 percent and the marshalling facilities 50 percent out of action. For comprehensive SHAEF BDA reports issued during the transportation campaign, see Spaatz Box 203, “Summary of Results of Attacks on Rail Transportation Targets, Report No. 5,” SHAEF Deputy Chief of Staff for Air, 23 May 1944, Part VII, which listed the percentages “out of action” for all major marshalling yards.

major waterways. This forced the Germans to unload the entire contents of trains stopped at these bridges, reload them onto barges, unload the barges on the far side of the river, and then either reload the equipment and troops on trains waiting on the far side of the river or road march their units to Normandy. The latter became the more common practice, with a variety of deleterious effects, after D-Day. In addition to reconnaissance photographs, Ultra provided a great deal of useful information on damage to bridges and the status of repairs. It also gave a clear indication of the effectiveness of bridge attacks when made *in combination with* attacks on marshalling yards.⁶²

Just how effective the combination of marshalling yard and bridge attacks was became clear in the days and weeks following Overlord, as German units from the strategic reserve in France and further afield tried to reach the front lines in time to throw the Allied armies back into the sea. Their failure to do so was a direct result of the transportation offensive. The 1st SS Panzer Division, for instance, left Louvain, Belgium, 17 June and did not reach Caen until 4 July, 17 days later. The journey involved 270 rail miles and another 140 miles by road. It would have taken three days under pre-attack conditions, but the bombing of marshalling yards at Ghent, Lille, and Maubeuge caused train delays of over a week. Attacks on rail centers around Paris then forced the division to detrain there and road march to the front. Along the way, the division met with further delays crossing the Seine River, where the bridges were down. As it turned out, this

⁶² Spaatz Box 203, SHAEF Deputy Chief of Staff for Air (Air Vice Marshal Robb), "Summary of Results of Attacks on Rail Transportation Targets, Report No. 5," 23 May 1944, Part III, "Summary of Attacks on Bridges with Provisional Results. For the role of Ultra in bridge attacks, see RG457, E9002, B12, Special Section, Military Intelligence Service, Special Research History (SRH) 017, "Allied Strategic Target Planning," August 1945, 19. The Military Intelligence Service was the forerunner of the National Security Agency. See also AIR 37/515, SHAEF G-2, Bridge Report No. 5, 5 July 1944. These reports listed damage to all bridges and anticipated repair time.

division arrived far too late to help throw the Allied armies back into the sea. It also arrived low on fuel, most of which it had used in the road march from Paris to the front.⁶³

Each German Panzer and Panzer Grenadier division at this time carried with it either three or four fuel increments (*Versorgungssätze*), each of which allowed the division to move 100 kilometers (62 miles) over dry paved roads. This division-level fuel reserve was intended to be available for use *after* the unit arrived at the front and began combat operations. In this case, however, 1st SS Panzer Division had to use well over half its fuel just to get to the front lines.⁶⁴ Once there, it found many fuel depots destroyed by fighter-bombers or depleted by other units. In addition, there was too little fuel arriving on trains, which could only be run in at night and then only if repair crews had managed to repair a bridge over the Seine long enough to get the train over and back before Allied aircraft attacked the bridge again.⁶⁵ To make matters worse for 1st SS Panzer and all other divisions, they had to demotorize by sending their entire complement of trucks to the railheads, now driven back 100 miles or more from the front by marshalling yard and bridge attacks, to haul fuel, ammunition, and rations back to the front. They did this at

⁶³ AIR 37/515, SHAEF/101GX/INT, "Move of 1 SS Panzer Division," 14 July 1944, 1-2; AIR 37/719, SHAEF, "Notes of Interference of Enemy Movements," 7 July 1944. See also AIR 37/719, Minute, Major Bennett to C-in-C AEAF (Air Chief Marshal Leigh-Mallory), 4 July 1944.

⁶⁴ See RG243, E2, Box 59, USSBS Military Analysis Division, *The Impact of Allied Air Effort on German Logistics*, 3 November 1945, 69, for a discussion of fuel increments. For additional insights on the German supply system, which proved inefficient at providing enough fuel in a timely manner to German combat units in both the West and the East, see RG243, E36, B187, CSDIC(UK), "A Survey of the Supply System of the German Army 1939-45," 25 August 1945.

⁶⁵ RG243, E36, B187, CSDIC(UK), "A Survey of the Supply System of the German Army 1939-45," 25 August 1945, 25. Ultra intercepts revealed the German procedures for running fuel trains in at night. See AIR 40/2073, AI3(e), "M.S.S. References to Oil Shortages and Restrictions since May 1944," 30 December 1944. See also RG243, E36, B191, Gen Omar N. Bradley and Air Effects Committee, 12th Army Group, *Effect of Air Power on Military Operations: Western Europe*, 15 July 1945, which notes that the Germans were able to run small fuel trains into Normandy at night as long as at least one railroad bridge was repaired and functional. The average delivery was about 1,000 cubic meters per night, which met the basic needs of about five heavy divisions. Gas for all the other divisions had to be obtained by truck convoys from locations as far away as Paris, Le Mans, and Rennes.

night, over bad roads, and under constant threat of air attack.⁶⁶ Finally, fighter-bombers targeted fuel tanker-trucks specifically, destroying most of them before their divisions made it into combat.⁶⁷ The result of these calamities for every German combat unit was a major fuel shortfall *from the outset*, and, as the effects of the oil offensive intensified during the summer, increasingly severe shortages. Indeed, the synergy between transportation and oil attacks caused fuel shortfalls that were *both* distribution-driven and the result of absolute shortages as fuel production plummeted.

By the time 1st SS Panzer Division and other German units went into the line in early July, the men were tired, had suffered serious losses from air attack, and went into combat in small packets rather than as integral divisions. Their heavy equipment, if it arrived at all, was worn down and constantly low on fuel. Many tanks and other vehicles broke down during the long road marches and were destroyed by fighter-bombers before repair crews could get to them.

The perils of 1st SS Panzer Division were representative of those endured by all combat units moving towards Normandy and indicated just how severely the combination of marshalling yard and bridge attacks had undermined the German army's ability to move, not to mention its ability to mass and maneuver. Once again, the cascading effects brought on by bombing did grievous harm to German combat units. The destruction of

⁶⁶ The best general account of the demotorization of German divisions in Normandy is Russell Hart, "Feeding Mars: The Role of Logistics in the German Defeat in Normandy, 1944," *War in History*, November 1996 3 (4), 418-35. The most compelling primary source is "A Crack German Panzer Division and What Allied Air Power Did to It between D-Day and V-Day," HQ 9th Air Force Advanced Prisoner of War Interrogation Unit (APWIU), located at MS16, S5, B12, F10. This was an in-depth interrogation of General Fritz Beyerlein, who commanded the elite Panzer Lehr Division. He emphasized repeatedly the serious operational difficulties brought on by the need to demotorize his division and send its trucks off to forage for fuel. Roundtrip supply runs often took three days or longer if road bridges were out of commission and were subject to SAS and Maquis ambushes as well as air attack.

⁶⁷ For an example of this problem, see MS16, S5, B12, F10, HQ 9th Air Force APWIU, "A Crack German Panzer Division and What Allied Air Power Did to It between D-Day and V-Day," 3-5.

marshalling yards and bridges (first-order effects) pushed back the railheads at least 100 miles from the front lines (second-order effects). This forced German units to de-train far from the front and make dangerous road marches for distances in excess of 125 miles, using up their fuel increments, wearing out their heavy equipment, and taking casualties from night-bomber and fighter-bomber attacks as they went (third-order effects). This in turn led to reduced combat power and cohesion as exhausted troops and worn-down equipment arrived in small packets and went into battle without unit integrity (fourth-order effects). Once on the line and already short of gasoline and ammunition due to inadequate or entirely absent rail shipments and the exhaustion of supplies in local depots, German divisions had to send their entire complement of trucks to railheads 100 miles or more from the front. These convoys traveled at night, over bad roads, and at constant risk of air attack or ambush by the SAS and Maquis, to bring back fuel, ammunition, and rations, in the process using up a great deal of already-scarce gasoline to get to the railheads and then back to the front—one of the glaring ironies in this situation (fifth-order effects). Despite these efforts, the Germans were always short on fuel and ammunition (sixth-order effects). They had just enough to wage a defensive battle along a static front, but their fuel shortage proved disastrous once the static front gave way to mobile warfare with the American breakout during Operation Cobra. The Germans quickly ran out of fuel and thus lost the vast majority of their vehicles in combat or during the retreat from the Falaise-Argentan Gap (seventh-order effects).

At each level in this assembly of cascading effects, *friction was always at work*, making the German position, already tenuous, even more so as units lost their dedicated truck transport and thus their ability to mass and maneuver; as those trucks were strafed,

broke down, or had accidents (a frequent problem driving at night, in convoy, on dark French country roads); as air attacks destroyed bridges and road junctions, forcing detours costly in time and gasoline; as armored vehicles, already in need of service after long road marches to the front, broke down and could not easily be repaired; and as fuel shortages, at first caused by problems of distribution, intensified as a result of outright scarcity once fuel depots were depleted or destroyed and the oil offensive reduced the amount of new supplies dramatically by August.

The 2nd SS Panzer Division quickly ran afoul of these cascading effects once it left Toulouse on 10 June. The division did not complete its movement to St. Lo until 2 July, after an odyssey of 22 days that encompassed 360 rail miles and another 100 road miles. Troops had to haul their tanks by rope, on flatcars, one at a time, over the only Loire River railroad bridge still capable of carrying them. This bridge was seriously damaged and unable to sustain the weight of an entire train but still passable for single flatcars and wagons. All the other heavy-gauge railroad bridges were down. Once the division was across the river, their 100-mile road march to the front took five days, during which they took significant losses from air and partisan attacks. They used up the majority of their fuel increments in the process.⁶⁸

The 9th and 10th SS Panzer Divisions departed Poland 12 June and, with exception of the heavy equipment, which slipped past Paris, had to detrain in eastern France and road march *400 miles* to the front, during which the motorized vehicles used up their fuel

⁶⁸ AIR 37/515, SHAEF/101GX/INT, "Movement of 2 SS Panzer Division," 8 July 1944, 1-2.

increments. The move from Poland to eastern France took five days; the move from there to the front took two weeks.⁶⁹

General Fritz Bayerlein's elite Panzer Lehr Division lost 130 of its 1,000 trucks, including 40 fuel trucks, each with a 2.5 ton capacity, *before* his division even made it to the front. Allied fighter-bombers were already singling out these tanker-trucks for destruction. During the road march north from 5-7 June, the division moved at night but was still attacked by night-bombers. Bayerlein constantly lost men and vehicles to these attacks and had to lead his division on long detours, which slowed down the move and caused accidents and wear and tear on equipment. In addition, the railheads were nearly 100 miles behind Bayerlein's division, forcing him to send trucks constantly on supply runs. These truck convoys took several days to complete a round-trip journey. This demotorization of Bayerlein's division severely restricted its tactical mobility, ability to shift reserves, and capability to launch any kind of attack or counterattack.⁷⁰

A similar pattern unfolded for the 17th SS Panzer Grenadier Division, which arrived at the front after nine days of rail and road movement; the 2nd Panzer Division, which required five days to get to the front; the 77th Infantry Division, which required 10 days; and the 265th Infantry Division, which spent nine days on the march.⁷¹ German prisoners of war had sketched the outlines of this problem clearly for their Allied captors by early

⁶⁹ AIR 37/719, SHAEF, "Notes of Interference of Enemy Movements," 7 July 1944. See also AIR 37/719, Minute, Major Bennett to C-in-C AEAF (Air Chief Marshal Leigh-Mallory), 4 July 1944.

⁷⁰ MS16, S5, B12, F10, HQ 9th Air Force APWIU, "A Crack German Panzer Division and What Allied Air Power Did to It between D-Day and V-Day," 29 May 1945, 3-5; AIR 37/515, SHAEF/101GX/INT, "Movement of Panzer Lehr Division," 7 July 1944, 1-2; RG243, E36, B191, 7371-7467, Gen Omar N. Bradley and Air Effects Committee, 12th Army Group, *Effect of Air Power on Military Operations: Western Europe*, 15 July 1945, 175-176.

⁷¹ See the following, all located in AIR 37/515: SHAEF/101GX/INT, "Movement of 2 Panzer Division," 7 July 1944; SHAEF/101GX/INT, "Movement of 17 SS PG Division," 8 July 1944; SHAEF/101GX/INT, "Move of 77 Infantry Division," 10 July 1944; and SHAEF/101GX/INT, "Move of 265 Infantry Division," 10 July 1944.

July, making it quite obvious that the Germans, having failed to throw the Allied armies into the Channel during the early stages of Overlord, would not be able to do so at all. The battle in the bocage became one of attrition, in which the Germans fought skillfully but with an increasingly strained and ultimately disastrous supply situation even as the Allies' logistical position and combat power improved.

In fact, SS *Obergruppenführer* Josef "Sepp" Dietrich, commander of 1st SS Panzer Corps, said the 73 days of action in Caen were the hardest of his career. During his defense of the town,

The supply problem became more and more difficult. Fuel and ammunition had to come more than 400 km [250 miles] over roads that were under the control of the enemy air force 24 hours a day. The losses of vehicles loaded with fuel and ammunition were felt severely, and deprived our defense of the necessary support. We could not mount any more attacks of our own." Clearly, even elite German units had too little fuel and ammunition to conduct anything other than a static defense... The supply problem became even more difficult because of the destruction of bridges, roads, and railroads.⁷²

A BDA report produced by USSTAF A-2 on 6 July summed up these effects of Allied bombing—and its effectiveness—succinctly: "The evidence is already conclusive that these operations have had a disastrous effect on enemy logistics."⁷³ The BDA reports produced by the ACIU, SHAEF, and the RRS, combined with Ultra intercepts and intelligence gleaned from interrogations of POWs, all underscored the fact that Allied intelligence personnel had a clear understanding that airpower was playing a key role in

⁷² RG243, E36, B185, 7th Army Interrogation of *Obergruppenführer* Josef "Sepp" Dietrich, Commander, 1SS Panzer Corps, 1944, 11 June 1945, 5-6. Although Dietrich provided these comments after the war, soldiers in his command who were captured by the British in July and August 1944 had the same things to say about the effects and effectiveness of Allied air attacks. In fact, POW interrogations often produced superb near-real-time BDA.

⁷³ MS16, S5, B12, F1, HQ USSTAF A-2, "Effects of Allied Air Power on First Month of Overlord Operations," 6 July 1944, 2.

the Normandy campaign. Reconnaissance photos and Ultra intercepts provided a nearly complete picture of the status of marshalling yards and bridges, the rates of repair, and therefore the proper moment to launch further attacks. With this level of intelligence support, the RTC was able to recommend the proper target priorities. Consequently, the Allies won the repair-versus-destruction contest by a wide margin.⁷⁴

In fact, Solly Zuckerman authored a study in which he determined that time required to reestablish through traffic at marshalling yards averaged seven days, while bridge repair took an average of 10 days, with severely damaged bridges averaging 16 days. Repairs also took longer on average after D-Day because repeated bridge attacks did increasingly severe damage to bridge structures, degraded the load-bearing capacity of surrounding earth, and, as the number of bridge attacks skyrocketed, spread repair crews thin. In addition, new reconnaissance cover of each bridge became available on average every 3.7 days, so there was rarely a case where the Allies did not know when a bridge would re-open and thus the optimum moment to attack it again.⁷⁵

As BDA reports were making clear, bombing of rail centers had already taken a heavy toll on the French railroad network prior to D-Day and had brought it to the point of severe crisis by July. An RRS damage assessment, itself based in part on a report by the SNCF Director General that had fallen into Allied hands just prior to his arrest by the Germans on D-Day, said a great deal about what the transportation offensive was doing to German logistics and combat power.⁷⁶ First of all, it noted that by the end of May, of

⁷⁴ See, for instance, AIR 37/719, 3652-3654, "Appendix 11: Repairs to Rail Bridges Up to July 8," July 1944.

⁷⁵ AIR 37/719, Professor Solly Zuckerman, "Times for Re-Establishment of Traffic through Bombed Rail Centres and Junctions and across Bridges," 11 August 1944, 1-2.

⁷⁶ Allied intelligence sources corroborated the major elements of this report.

19 major marshalling yards in northeast France and around Paris, only three were working at 100 percent of pre-attack capacity, one at 70 percent, three between 15 and 40 percent, and the other 12 at 10 percent or less. The number of serviceable locomotives dropped from 15,927 to 11,300, many of which were damaged and could not be repaired due to the destruction of locomotive repair shops. Even more telling, the number of serviceable wagons decreased from 434,000 to 203,000. Air attacks prior to D-Day had also destroyed 72 miles of track, but very few repair rails were available, and most of those were obtained by dismantling existing rail lines. In addition, 74 bridges and tunnels were out of service and another 11 partially unserviceable, nearly all of them along the vital Seine and Loire Rivers. Of 467 locomotive repair sheds, 70 had been destroyed, 20 rendered temporarily unusable, and many more damaged. The SNCF's train-miles per day dropped from 104,780 on 1 November 1943 to 71,300 on 1 May 1944. Also important, though not good for relations with the French, air attacks had killed 1,262 and wounded 4,040 SNCF workers by 1 May, many of whom were not easy to replace. To reduce losses of engines and wagons in the Northern Region, on 2 May the Germans began diverting most traffic to the East and Southeast Regions, causing serious delays for troops and supplies heading to Normandy, which now made a circuitous journey through eastern and central France, only to be stopped at the Loire River, where the bridges were down. It was here, after D-Day, where truck convoys came to collect supplies.⁷⁷

⁷⁷ AIR 37/719, RRS, "French National Railways (S.N.C.F.) Position, June 1st 1944," 10 August 1944, 1-5. It is very important to note that, although this document was not published until August 1944, the RRS had a copy of the SNCF Director's report by early June. This meant RRS analysts knew with great accuracy what bombing was doing to the French railroad network from March to June 1944 and made appropriate targeting inputs to the Railway Targets Committee, which recommended target priorities to Tedder and Leigh-Mallory.

An SNCF Department Head wrote the Director a memo in early May, a copy of which also fell into Allied hands, with the following observations about Allied bombing:

Bombardment operations relating to transport [are] perfectly conceived and realized. If we, who belong to the S.N.C.F., had to practice a sabotage of the same character, we would not do any better. Disorganization is progressive and irreparable. The Allies make work necessary and know how to adjust their raids to await the repercussions of previous raids. When one speaks of working resumed, it means that we made a train pass...These recent days...movement of troop trains is totally interrupted...The Germans were furious. It would be impossible now to pass a division from north to south or south to north.⁷⁸

By the third week of May, traffic through the stations north of Paris was down from 186 trains per day to 61. Only small trains could sneak through between attacks. By D-Day, serious locomotive and crew shortages had idled 1,017 trains. By 9 June, 1,278 trains were idled. In fact, only 495 trains moved during all of June, an 87.5 percent reduction in traffic. Damage to rail centers drove a requirement to shift from large trains capable of carrying a division (60-90 wagons) to small trains carrying small units (3-18 wagons). It also caused delays, diversions, and circuitous routing, playing havoc with German efforts to move troops and supplies.⁷⁹

These German supply woes were clear to Allied intelligence officers during the campaign as a result of POW interrogations, reconnaissance photographs, and Ultra intercepts. Colonel Hans Hoeffner, a senior logistics officer, later provided an even more complete picture of German logistical difficulties. He related that German forces in the field required 7,000 tons of supplies per day, 5,000 tons of which were supposed to come by train and the other 2,000 by truck. However, only three military trains per day entered

⁷⁸ Ibid., 6.

⁷⁹ AIR 37/719, RRS, "French National Railways (S.N.C.F.) Position, June 1st 1944," 10 August 1944, 7-8.

the battle area on average, delivering about 1,400 tons, while another 700 tons moved by barge down the Seine from Paris to Rouen, and another 1,200 tons by truck convoy—a total of 3,300 tons. Hoeffner further noted that given the weakened state of German divisions in the line, the minimum requirement for supplies was probably closer to 5,250 tons. Still, this left a shortfall of 1,950 tons. Given this disastrous situation, the wonder is that German troops were able to resist as effectively as they did. Finally, Hoeffner said supply shipments contained 70 percent ammunition, 20 percent fuel, and 10 percent rations, underscoring the degree to which German operations were static and defensive.⁸⁰

In two subsequent reports, the RRS completed its assessment of the effects and effectiveness of the transportation campaign. The first of these noted that during the entire month of July the Germans moved 395 trains, an average of 13 trains every 24 hours in all of France. Of 67 fuel trains dispatched by end of June from Strasbourg, only four made it to forward fuel depots. The rest were rerouted to more distant points to unload their cargoes, making for even longer supply runs by truck convoys. Virtually every train had to be rerouted far to the south and east, and then north and northwest to the battle area. These detours led to major delays, greater stress on locomotives, serious fatigue for the shrinking pool of SNCF workers, and hence greater friction at all points in the transportation effort. Reconnaissance cover allowed the Allies to see when trains were forming up, when the units they were to transport arrived at the marshalling point, and when the optimum time for attack—as the trains were loading—had arrived.⁸¹

⁸⁰ AIR 40/1345B, APWIU (9AF Advanced) Interrogation, , 31/1945, "The General Military Transport Organization in France, 1944" 6 March 1945.

⁸¹ AIR 37/719, RRS, "German Military Movements by Rail in France and Belgium: July, 1944," 14 September 1944, 1-3.

The critical locomotive shortage brought on by Allied bombing in the West forced Germans to bring 200 locomotives from the East, where they were sorely missed in the effort to move troops and supplies during the Russian summer offensive. Even more ominous was the impact of the railroad crisis on their units in southern and southwestern France once Operation Anvil (Dragoon) placed Allied troops in southern France, threatening to cut off German troops there.⁸²

Just before Operation Anvil, Eaker, now commanding 15th Air Force in Italy, cabled Spaatz a list of 12 bridges that had to be knocked out to achieve complete railroad interdiction prior to the Anvil landings. These bridges were knocked out of action in the days before the invasion.⁸³ The end result for German units of the 19th Army in southeastern France was a disaster in which they quickly ran out of fuel (as none was coming through from major depots in Germany and northeastern France), had no rail transportation, and were thus forced to flee, for the most part, on foot. A few had motorized vehicles, but these came under fighter-bomber attack and were destroyed or ran out of fuel and had to be abandoned.

The magnitude of the disaster was conveyed by a POW who had served as a private in a German artillery unit. On the road from Nimes to Belfort, he said,

burned-up military trucks could be seen constantly at intervals from 50 to 100 meters. Most of them were supply trucks which had been loaded with gasoline, oil, munitions, and food. It was remarkable to note that just these trucks loaded with gas and oil were most commonly recognized, attacked, and destroyed...Along the entire route of our unit, the damage done by American planes was terrific. Thousands of trucks, hundreds of horses and wagons were destroyed. Several motorized units lost all their

⁸² Ibid., 4-5.

⁸³ MS16, S3, B4, F1, Cable, Eaker to Spaatz,, 13 August 1944.

vehicles in a few minutes and had to take horses and wagons from the French in order to proceed further.⁸⁴

This was yet another case of the cascading effects produced by heavy bomber attacks on French marshalling yards and bridges. Had the major rail centers and bridges not been almost entirely destroyed by Allied heavy bombers, this soldier's division would have ridden on trains, at night, and therefore in relative safety from Allied fighter-bomber attacks. As it was, they had to get out of southeastern France quickly, and the only way to do that was by vehicle, horse-drawn wagon, bicycle, or foot. To stay ahead of advancing Allied columns from both the west and south, they had to keep moving even during daylight hours, and this was their undoing. Most of the men reached the frontiers of Germany and were later re-equipped (although not as well as previously) to fight in the war's closing campaigns, but they lost nearly all of their equipment and, somewhere along the back roads of southern France, their last hope for a German victory.⁸⁵

The same problem developed in southwestern France, where a German 1st Army troop column of approximately 100,000 men began an evacuation at the beginning of September and was discovered by Allied reconnaissance aircraft in the area of Nevers, Bruges, and Poitiers, moving northeast mostly on foot. Four 8th Air Force fighter groups began strafing operations, and from there the disaster befalling this forlorn column was complete. Those who survived the strafing and bombing over the next several days were

⁸⁴ Eaker B I:30, F7, 12762-12775, HQ MAAF, Intelligence Section, "What the Germans are Saying," 1945, 10 (no page numbers, but located 10 pages into the text).

⁸⁵ During a tour of the Reich's western defenses, Albert Speer sent a memo to the Führer on 15 September 1944 stating that "The lack of heavy weapons felt by the army on the Western Front is shocking... There is a terrifyingly large number of weaponless soldiers in the West." See AIR 20/8780, Control Commission for Germany (BZ), Field Information Agency, Report No. 62, Interrogation of Albert Speer on "The Effects of Aerial Warfare and Allied Successes on German War Production" (interviewed on 6 September 1945), 8 November 1945, 11.

almost all captured once American columns moving southeast from Normandy and northwest from their Anvil beachheads cut them off. The fact that the majority of these 100,000 soldiers were *walking*, not riding trains or trucks, served as further proof that the transportation campaign had by this time destroyed the French railroad network and run the German army out of gasoline. The railroads, already a complete shambles, were incapable of transporting these soldiers trying to run the gauntlet between advancing Allied armies. They had a 450-mile walk ahead of them if they were to reach the German frontier. The "traffic desert" (*Verkehrs Wüste*), as von Rundstedt called it, created by Allied bombing of marshalling yards, bridges, and canals, once again cost the Germans dearly. Few who survived the strafing attacks managed to reach Germany. The Allied transportation offensive thus cost the Germans another 90,000 troops who spent the rest of the war in Allied POW camps rather than fighting on for Reich and Führer.⁸⁶

By the end of August, as noted in the third and final RRS report, intelligence personnel had seen "the final petering out of German formation movements on the S.N.C.F. and Belgian State Railways...the study of which has been undertaken by this Service ever since adequate information became available towards the close of 1941."⁸⁷ This revealing passage not only confirmed the demise of organized rail movement, but also the vital fact that the RRS had been studying the French and Belgian railroads for nearly *three years* before the transportation offensive. They understood the SNCF's strengths and weaknesses, with the latter influencing how the Allies planned and

⁸⁶ MS16, S3, B4, F2, Cable, Spaatz (USSTAF Forward) to Anderson (USSTAF Rear), 3 September 1944.

⁸⁷ AIR 37/719, RRS, "German Military Movements by Rail in France and Belgium: August, 1944," 13 October 1944, 1

executed this decisive campaign. Access to superb reconnaissance photos, and the ACIU K and F reports based on them, made RRS analysts' jobs much easier.

Only 294 trains moved during August 1944, down from 535 in June and 395 in July. By this time, nearly complete paralysis of the French and Belgian railroad networks had set in, with troop delays, detours, and a high threat of attack by night-bombers and fighter-bombers the rule. Continuing air attacks on marshalling yards, bridges, viaducts, and canals reduced remaining transportation capabilities in France to nearly nil.⁸⁸ Canals were not on the original target list but were added in July, once SAS teams in France discovered the Germans were using barges on the Seine and the Loire Rivers to transport troops and supplies into Normandy under cover of night.

9.4 The Bombing-SAS-BDA Feedback Loop: Increased Effectiveness

The British had long planned to employ large numbers of SAS teams, each with 5-10 men and working with the Maquis, to cause as much damage as possible to the German military in France after D-Day. These teams were trained to attack trains, truck convoys, vehicle parks, and supply depots. They were also tasked to report on enemy troop movements and the effects of air attacks. Planners envisioned an SAS force in France of between 2,250 and 2,900 men. The SAS teams, working with the Maquis and American Jedburgh teams made up of OSS operatives, had French and Belgian interpreters assigned. Also, and of vital importance for the near-real-time SAS BDA inputs that became so valuable during the transportation campaign, each team had a secure radio communications capability. Also significant for the success of the transportation campaign was an SAS operations order stating that "All fuel dumps and fuel storage

⁸⁸ Ibid.

facilities supplying B Echelons of certain armoured divisions will be considered in detail and attacked. Roads leading to alternative dumps will then be ambushed.”⁸⁹ This was another clear indication, along with the targeting of fuel tanker-trucks and fuel trains, that Allied leaders sought to maximize the synergy between transportation and oil attacks.

At the fifth meeting of the AEAFF Bombing Committee in January 1944, the key agenda item was a discussion of how best to coordinate bomber raids on rail centers, SOE sabotage, and SAS direct-action missions. All agreed that close coordination would be required to maximize the effects of these attacks, and the SOE representatives as well as their SAS counterparts agreed to focus on railroad lines and signaling devices within 150 miles of the battle area. From the outset, then, bombing and special operations were closely connected both operationally and in terms of the BDA feedback loop.⁹⁰

By early July, there were 57 SAS teams and 13 Jedburgh teams in France and Belgium. They planned to arm 35,000 Maquis by 1 August and had 8,456 air-dropped containers full of arms with which to do so. The SAS and Maquis wasted no time in destroying railroads and German supply convoys. On 6 July, they destroyed four railroad bridges, cut major rail lines in 24 locations, and attacked supply convoys from ambush with explosives, tire bursters (spikes), and small arms. On 9 July, they wrecked 46 locomotives, one train, and three more bridges.⁹¹

⁸⁹ AIR 37/513, 21st Army Group, “Operational Use of SAS Troops,” 20 December 1943, 1-4 and Appendix A. total strength in France never reached the anticipated figures. A total of 1,037 men, 72 of whom were Americans assigned to Jedburgh Teams, served in France. However, the Maquis proved more capable—and become so more quickly—than anticipated, which could have caused the British to send fewer SAS teams than originally planned.

⁹⁰ AIR 37/512, 3842-3843, “Minutes of the Fifth Meeting of the Allied Air Force Bombing Committee...on 18 January,” 18 January 1944, 1-2.

⁹¹ Spaatz Box 119, “Development of Resistance in France,” 6, 9, and 14 July SAS reports from the field.

A particularly important report from the field, sent on 22 July, noted that SAS teams had sabotaged a number of locks along the Seine River canal system. Their recent discovery that the Germans were using canals by night to move troops and supplies into Normandy resulted not only in SAS actions such as this one, but also in belated day and night bombing of key canal locks and other infrastructure, with SAS teams advising airmen when barges were fully loaded and hence lucrative targets. Equally important was a report, two days later, that SAS teams had started targeting German fuel trains and depots; in this case, they reported destroying 224,500 gallons of gasoline at a depot in the Pas de Calais. On 27 July, they set fire to a train carrying 158,500 gallons of gasoline, destroying it and blocking the railroad tunnel where it had sheltered from fighter-bomber attacks. The Germans had begun hiding their fuel trains in this fashion, making them safe from air attack, but not from the SAS and Maquis, who went after them relentlessly. On the same day the Maquis annihilated a column of 116 trucks on a supply run in the Saone-Loire department. In addition, SAS teams destroyed more canal locks on the Seine, holding up shipment of fuel to the front, and the Maquis destroyed several barges carrying 100,000 gallons of fuel on the Nievres River near its confluence with the Loire. Finally, another 264,100 gallons of fuel were destroyed in numerous smaller attacks against the German logistical system. Taken together, these attacks destroyed nearly 400,000 gallons of fuel and represented a banner day in the unremitting Allied effort to deplete German fuel stocks.⁹²

⁹² Spaatz Box 119, "Development of Resistance in France," 22, 24, and 27 July SAS reports from the field. In addition, see MS16, S3, B4, F1, Cable, HQ AIR TPS to EXFOR and AEAF, 8 July 1944, which noted that "SAS report Germans are moving barges from Brittany to Nantes along the River Blavet and then down the canal from Brest to Nantes. The barges when they arrive are for use as pontoon bridges on the Loire. SAS recommend blocking the locks on the Blavet by bombs when there are barges in them. They

The pace of SAS and Maquis attacks picked up in August with the destruction of 70 railroad fuel tank cars on 5 August. The average tank car carried about 8,000 gallons of fuel, so this represented the destruction of another 560,000 gallons of gas, a loss the Germans could ill afford at this point, with their own vehicles short of fuel in the Avranches-Falaise areas and thus unable to engage in maneuver warfare with Allied forces involved in the breakout. On 12 August, the SAS destroyed another 396,150 gallons of fuel in tank cars. The attacks on fuel continued with an 8 September SAS raid at Foulain destroying 211,280 gallons. On 13 September, the Free French Insurgents (the new title for the Maquis) destroyed another 211,280 gallons.⁹³

Several things become apparent from even a cursory look at these SAS operations reports. First and foremost is the serious damage done by SAS and Maquis teams to German logistical assets and lines of communication. These small and integrated teams of elite special-operations forces and indigenous guerrilla fighters destroyed bridges, cut rail lines, blew up canal locks, and cut telegraph and signaling lines at will throughout France. These attacks intensified the effects of heavy bomber and fighter-bomber attacks by slowing the movement of German troops and supplies towards the front and making them vulnerable to SAS and fighter-bomber attacks as they waited for bridges and railroad tracks to be repaired or made their way slowly to the front. The second fact that becomes apparent is the heavy emphasis the SAS and Maquis placed on destroying German fuel stocks whenever possible. In this sense, SAS attacks were extensions of the

would let us know when lock is full." This was the first indication the Germans were using barge traffic. The 22 July 1944 SAS report from the field (sent two weeks later) confirmed that they were doing the same thing on a large scale over the Seine River.

⁹³ Spaatz Box 119, "Development of Resistance in France," 5, 9, and 12 August, and 8 and 13 September SAS reports from the field.

transportation and oil offensives. Third, and most important, these SAS actions represented a fourth-order effect of heavy-bomber attacks, which destroyed key marshalling yards (first-order effects) and pushed the railheads back nearly 100 miles from the front (second-order effects). This forced the Germans to use trucks and barges to move fuel, and to decentralize and camouflage their fuel dumps, which made them safer from air attack but more vulnerable to SAS and Maquis attacks (third-order effects). These cascading effects gave the SAS and Maquis a target-rich environment in which small and easily attacked German truck convoys, fuel trains, fuel dumps, and barges could be picked off with regularity (fourth-order effects). The transportation campaign against marshalling yards and bridges thus proved highly effective because it created the conditions in which night-bombers, fighter-bombers, and SAS teams could destroy German fuel stocks faster than the Germans could replace them from current production, which was plummeting by July as a result of the oil campaign that had begun on 12 May.

9.5 Transportation Campaigns, BDA, and the Iterative Learning Process

During the transportation campaign in Sicily and southern Italy, Zuckerman observed that concerted attacks on marshalling yards paid the greatest dividends. Although he overlooked bridge attacks, General Spaatz and Air Chief Marshal Leigh-Mallory's AEF staff did not, and as a result both came under heavy attack in France and Belgium. Zuckerman had foreseen how heavy-bomber attacks on rail centers might produce synergistic effects once railheads were pushed back from the front and German army units as well as supply convoys could be caught on the move by night-bombers and fighter-bombers. By September 1944, there was no doubt about the decisive nature of the transportation offensive, and several Allied intelligence organizations soon set to work

drawing lessons from it. The *ex post facto* BDA reports they produced drove an iterative learning process put to very good use during the last and greatest of the transportation campaigns, which destroyed Germany's railroads and canals so thoroughly that it brought about a collapse in the German war economy, facilitating a faster and less costly victory.

9.6 Verifying BDA: Allied Ground-Survey Teams and Iterative Learning

The ground survey teams established by the AEF and USAF to study the effects and effectiveness of bombing during the transportation campaign had three goals. The first was to verify the accuracy of BDA reports produced during the campaign to determine how their utility and accuracy could have been improved. The second was to determine how well munitions worked against different targets. The third and most important was to apply lessons learned from these surveys to the planning for and execution of transportation attacks against the Reich and the ongoing oil offensive. There were four groups involved in this process: the Bombing Analysis Unit (BAU), which was directed by the AEF (and later SHAEF) but staffed primarily by British BDA experts; the USAF Air Evaluation Board (AEB—predecessor of the United States Strategic Bombing Survey); a French ORS dedicated to studying the effects of Allied bombing; and small teams sent in by the USAF to survey bomb damage from missions flown by aircraft assigned to their commands. These small teams went in first and fed reports to their owning commands, and to the BAU and AEB, thus acting as BDA subcontractors.

One of these small teams was a Third Bombardment Division unit led by Major Mark Brown, the division's chief photointerpreter. He and his team studied the effects of their air division's bombing on marshalling yards such as Trappes; petroleum, oil, and lubricants (POL) storage sites such as Gennevilliers, a major facility outside of Paris; and

bridges such as the Amizy railroad bridge. During their surveys, they took photographs of damage, interviewed French workers, and produced detailed damage assessments. The reports from Trappes and Gennevilliers provided a wealth of information on the effects of Allied bombing. The railroad bridge at Amizy also yielded some vital information about "hidden" structural damage. The bridge was bombed by 45 aircraft carrying 118 2,000-pound general-purpose bombs fused 1/10th second in the nose and 1/40th second in the tail. There were no hits but two near misses at one approach to the bridge. Although reconnaissance cover showed no damage, in reality the bridge was seriously damaged. The shock waves and earth movement caused by the near misses pushed the west abutment 13 inches to the east, shearing the rivets that anchored the end of the bridge and pushing the ends of the bridge apart 7 ¾ inches. This meant the bridge would require major repairs before it could be used for fast and heavy traffic. In addition, the huge craters made by 2,000-lb. bombs with this fuse combination—60 to 70 feet in diameter and 20 to 30 feet deep—tore up tracks and grade all around the bridge. Filling these craters, which was a prerequisite for repairing the tracks, required large repair teams working for a period of several days.⁹⁴

There were three important lessons for photointerpreters. The first was that not all serious damage is visible, especially in vertical as opposed to oblique photographs. The second was that the effort required to fill-in large craters and repair track had to be taken into consideration when making judgments about the time required for bridge repairs. The third was that watching traffic patterns closely after such an attack, whether by

⁹⁴ SMS347, S1, B2, F1, USSTAF (3rd Bomb Division), Ground Survey Report, Major Mark Brown, analysis of Amizy Railroad Bridge, France, based on ground survey team photographs, August 1944.

sending reconnaissance aircraft over the target to observe traffic visually, by analyzing vertical or oblique photo over a period of days, or by relying on special operations teams, would reveal whether there was "hidden" damage.

Reports such as the ones produced by Major Brown's team went to their parent units and to the BAU and AEB, which quickly developed a close working relationship. Both evolved rapidly after their activation in August and together comprised over 200 personnel. The BAU's experts were assigned from major BDA-producing organizations, including RE8, MEW, the RRS, and the ACIU. They were organized into a self-supporting, motorized unit fielding five detached parties for ground surveys. The BAU was commanded by Group Captain E.S.D. Drury, the Chief Armament Officer for AEAf. His Scientific Director was Solly Zuckerman.⁹⁵

The first teams arrived in France in September 1944. Each had eight men, including four BDA experts and a targets intelligence officer, who followed a three-phase process during each survey. They assembled all attack data (number of attacks, numbers of aircraft and bombs in each attack, and bomb-fuse combinations), interviewed people with information about the effects of attacks, and conducted field work. Zuckerman and his scientific team, comprising four officers and several bomb census experts who had done this work in 1940 with German bombing of the UK, turned the mountain of BDA data collected by survey teams into useful reports. Brigadier General J. Fickel, Chief of the AEB, offered the BAU office space in the same building as his unit near Paris. The BAU-AEB liaison soon included combined survey teams, compilation of survey results

⁹⁵ AIR 37/1108, BAU, "History of the Bombing Analysis Unit to the end of November 1944," 18 December 1944, 6-8.

into target-specific dossiers, collective analysis of materials, and collaborative production of finished reports. A combined committee, chaired by Drury and Fickel, met every two weeks to select targets for surveys and review completed survey reports.⁹⁶

Zuckerman and his scientific advisors made frequent visits to London to collect target materials and conduct liaison work with other agencies and commands, as did members of the various ground survey teams. They also relied heavily on data provided by the SNCF, which detailed seven scientific experts to work on the BAU. The formal reports produced with their assistance were widely distributed and reached all BDA-producing organizations. By the time the transportation offensive against the Reich began in November, targets officers, staff planners, and BDA experts had made good use of the many BAU-AEB formal BDA reports to maximize the effects and effectiveness of this last and greatest air campaign against Nazi Germany.⁹⁷

The single most impressive product of this iterative learning process was the first Bombing Analysis Unit (BAU) report, published in early November, just before the transportation campaign against German railroads and inland waterways began. The report contained a wealth of BDA-derived insights on the reasons for the success of the transportation campaign against French and Belgian railroads. These influenced various aspects of the transportation campaign against the Reich. This was iterative learning at its best, and the result was a transportation offensive against Germany that went after marshalling yards (with special emphasis on locomotive repair shops), key bridges and viaducts, and canals.

⁹⁶ Ibid., 14-19, 29-30.

⁹⁷ Ibid., 35-40.

The report noted that the campaign had validated the idea that marshalling yards formed the key target set for transportation campaigns. Attacks on these installations had damaged not only repair sheds, but also the full range of support infrastructure needed to keep trains running, including marshalling facilities, through lines, signaling and telephone equipment, water supply, and coal supply. Attacks on bridges, which were seen as means for imposing more serious interruptions of through traffic than could be achieved with marshalling yard attacks, proved to be the ideal and indispensable companion target set⁹⁸ The BAU report also emphasized how effectively the twice-daily SHAEF target-selection meetings were. These venues, in which intelligence officers and civilian experts from the RRS brought the latest sources to light, allowed senior air and ground commanders to pick the proper targets for upcoming attacks. This was, in effect, the World War II version of rapid retargeting, and it worked well. Allied leaders would employ this committee process again for the transportation offensive against the Reich, just as they were already doing for the air offensive.⁹⁹

The report also confirmed the synergy between heavy-bomber and fighter-bomber attacks. As rail centers and their engine repair depots succumbed to heavy-bomber raids, fighter-bomber attacks on running trains reached 500 to 600 per day in the month

⁹⁸ AIR 37/1261, B.A.U. Report No. 1, "The Effects of the OVERLORD Air Plan to Disrupt Enemy Rail Communications," 4 November 1944, 1-5. For a number of useful statistical representations of these bridge attacks, see AIR 40/317, 3912-3994, 1st Operational Research Group, "Bombing Attacks on French Railways from January to August, 1944," Part II: Bridges, 1944. The six major Seine River bridges were all cut by 28 May and remained so for all but 10 days of the entire campaign. Their closure rate was 97.5 percent. Attacks on the 10 major crossings over the Loire River, which began on D-Day, resulted in a 78 percent closure rate for the entire campaign. The eight bridges over smaller rivers in the gap between the Seine and Loire were closed on average only 70 percent of the time, which allowed the Germans to bring up just enough troops and supplies to wage their static defensive effort. The report also noted that large bombs dropped by heavy bombers were much more effective on all types of bridges; least effective were fighter-bomber attacks on masonry bridges with their smaller bombs.

⁹⁹ AIR 37/1261, B.A.U. Report No. 1, "The Effects of the OVERLORD Air Plan to Disrupt Enemy Rail Communications," 4 November 1944, 4-5.

following D-Day. These attacks, which were mostly within 100 miles of the front lines, complemented attacks by heavy and medium bombers. They caused a precipitous fall in the volume of traffic that began in the middle of March and by D-Day was about 30 percent of January levels. Traffic dropped to 10 percent of January levels by the beginning of July and stayed there for the rest of the campaign.¹⁰⁰

On a closely related note, Zuckerman stated with great satisfaction that "French and German records testify to the extreme and immediate sensitivity of traffic-flow attacks of rail centres. In this respect the complex rail network of France and Belgium behaved no differently from the much simpler railway system of Sicily and Southern Italy."¹⁰¹ The report listed four key factors in the success of the transportation offensive: destruction of locomotive repair facilities, destruction of marshalling facilities, blocking of through routes, and attacks on running trains. "One fact that stands out plainly," it said, "is that the fall in locomotive power and the loss of repair facilities, due to the attacks on depots, played the overwhelming part in reducing the railways in a very short time to a state of catastrophic collapse."¹⁰²

¹⁰⁰ For a number of useful statistical representations of these effects, see AIR 40/317, 3912-3994, "Bombing Attacks on French Railways from January to August, 1944," 1st Operational Research Group, Part I: Overall Effects on Through Travel, 1944. This report noted that the mean duration of total interruption of through traffic caused by attacks on marshalling yards was 84 hours for raids dropping under 100 tons of bombs and 127 hours for raids dropping over 100 tons. The figures for tracks in open country were 58 hours for bombing attacks and 23 for acts of sabotage. These figures are impressive in view of the fact that attacks on rail centers were timed to take place just as repair crews were finishing their work. The combination of reconnaissance photographs, Ultra intercepts, and these mean-duration-of-interruption figures gave planners both firm intelligence, and, on the rare occasions when that was not forthcoming, a mean figure to work with as they planned further attacks. The mean times of interruption for lines in open country, while not as impressive, take on a new light when we recall that fighter-bombers were making 500 to 600 attacks a day on these lines. Repair crews simply faced an impossible task.

¹⁰¹ AIR 37/1261, B.A.U. Report No. 1, "The Effects of the OVERLORD Air Plan to Disrupt Enemy Rail Communications," 4 November 1944, 34.

¹⁰² *Ibid.*, 35.

The report concluded in words that could only have been Zuckerman's: "It seems clear from present conditions in N.W. Europe that the importance of railways relative to other strategical target systems is in fairly direct ratio with the part they play in the maintenance of a country's economic, social and military life."¹⁰³ Here was the clearest indication of all that Zuckerman and Tedder recognized the vulnerability of Germany's railroads and canals, and that they would rely heavily on BDA from the campaign in France to plan the upcoming effort against the Reich, just as they had used BDA from Italy to help them plan attacks in France. Unlike the experience of the First World War, where only *postwar* bombing surveys were made, during World War II Zuckerman and Tedder directed several *post-campaign* bombing surveys, first in North Africa (a small but useful baseline study); then in Sicily and southern Italy; and finally in France and Belgium. Their aim, which they clearly achieved, was to apply these lessons, *through an iterative learning process*, to future campaigns. The result was a growing body of vital BDA-related intelligence, which the Allies put to good use in target selection, bombing operations, and in gauging the effects and effectiveness of their bombing campaigns.

An Allied intelligence report produced after the war echoed the BAU's findings regarding the effects and effectiveness of the transportation campaign in France:

Evidence from all sources clearly indicates that the continuous aerial attacks on transportation facilities prevented the enemy from effectively concentrating his men or material at critical times and places. Transport proved to be the weakest link in the logistics chain, its failure was the immediate cause of the breakdown of the supply system, and consequently was a decisive factor in the collapse of the German Army.¹⁰⁴

¹⁰³ Ibid.

¹⁰⁴ RG243, E2, Box 59, USSBS, Military Analysis Division, *The Impact of Allied Air Effort on German Logistics*, 3 November 1945, 5.

One other related finding of great importance was the synergistic effect between transportation and oil attacks once the oil offensive began on 12 May. Until the end of July, most of the German fuel shortages in Normandy were driven by distribution problems, in other words, by the collapse of the transportation network under concerted air attack. By August, however, the problem became increasingly one of absolute shortage rather than distribution. The Germans did themselves no favors in this process when they failed to move two of their three largest surface fuel depots, which were located at Paris-Argenteuil, Bordeaux, and Lyon, into tunnels. They stored the fuel from the Paris depot in subway tunnels but did nothing with the stocks at Bordeaux and Lyon, both of which were destroyed by Allied bombers on 2 August with a loss of 1,850,000 gallons of fuel, or *two-thirds* of the strategic reserve in France.¹⁰⁵

The growing gasoline shortfall began playing a part in the ground campaign immediately after the American break-out from the St. Lo-Perriers road from 25 to 27 July. The movement of German units from Caen to Mortain was hampered by lack of fuel, and the counterattack there was delayed waiting for gasoline, which never arrived in adequate quantities. The result was an operational disaster as the German attack failed, the Allied advance continued, and the closing of the Falaise-Argentan gap forced the fuel-starved German armies to retreat. During their flight towards the frontiers of the Reich, the Germans abandoned thousands of vehicles for lack of fuel. Armored and mechanized divisions lost on average 50 percent of their motor vehicles, 70 to 100 percent of their armored vehicles, and 60 to 70 percent of their towed artillery. By the

¹⁰⁵ Spaatz Box 134, HQ 12th Army Group Interrogation Center, "Effects of US Strategic and Tactical Air Power," based on interrogations of *Generalleutnant* Zimmermann (von Rundstedt's Director of Operations), *General der Kavallerie* Westphal (von Rundstedt's Chief of Staff), and *Oberst* John (Director of Logistics), 12 June 1945, 4.

end of September, the German soldiers lucky enough to have made it to the German border were critically short of heavy equipment. They lacked the fuel required to retreat from France, and they never again had adequate quantities of it during the war's closing campaigns. As *Generalmajor* Toppe, Quartermaster General of the German Army, noted, by September 1944 available supplies were far short of requirements even with rigorous economy measures. In a telling statement, Toppe summed up the effects of fuel shortages on the German army's ability to wage war: "German commanders agree that a considerable part of the art of war consists of concentrating more force at key points than the enemy; when mobility and maneuver are lost, the loss of battles and campaigns follows."¹⁰⁶ *Generalfeldmarschall* Gerd von Rundstedt, Commander-in-Chief of German armies in the West, characterized the effects of Allied bombing on German operations in France as "*katastrophal*."¹⁰⁷ This was perhaps the most eloquent, if also the shortest, appraisal of the transportation campaign's effectiveness.

¹⁰⁶ RG243, E2, Box 59, USSBS, Military Analysis Division, *The Impact of Allied Air Effort on German Logistics*, 3 November 1945, 140; RG243, E36, B191, Gen Omar N. Bradley and Air Effects Committee, 12th Army Group, *Effect of Air Power on Military Operations: Western Europe*, 15 July 1945, 10-11, 181.

¹⁰⁷ RG243, E36, B244, 7535-7547, HQ 12th Army Group, Mobile Field Interrogation Unit No. 4, interrogation of *Generalfeldmarschall* Gerd von Rundstedt, in "PW Intelligence Bulletin on Effects of US Strategic and Tactical Air Power," 20 May 1945, 9.

CHAPTER 10

THE ATTACK ON OIL, APRIL – DECEMBER 1944: BDA AND THE BEGINNINGS OF GERMAN DEFEAT IN THE FIELD

He who owns the oil will own the world, for he will rule the sea by means of the heavy oils, the air by means of the ultra-refined oils, and the land by means of gasoline and the illuminating oils.¹

- Henri Bérenger, French diplomat, 1921

With the attacks on the hydrogenation plants, systematic raids on economic targets have started at the most dangerous point.²

- Albert Speer to Adolf Hitler, 30 May 1944

Today we have finished rebuilding the plants and tomorrow the bombers will come again.³

- Saying among repair crews at oil plants

10.1 Keeping an Eye on Oil: Assessing Its Importance and Vulnerabilities

Just after the end of the war in Europe, General Spaatz noted that

The air attack on Germany's oil production and distribution system stands out as the one clear-cut fulfillment of the theory of precision 'Strategic' attack. This attack, once it was started, was carried out relentlessly and continuously until a vast and complex industry, vital to the conduct of virtually every branch of the enemy's war effort lay all but prostrate.⁴

The ensuing fuel shortage had a catastrophic effect on Luftwaffe and German army operations. In fact, the attack on oil succeeded largely because of the basic weaknesses

¹ Quoted in Robert Goralski and Russell W. Freeburg, *Oil & War: How the Deadly Struggle for Fuel in WWII Meant Victory or Defeat* (New York: William Morrow and Company, Inc., 1987), 13.

² AIR 20/8780, Control Commission for Germany (BZ), Field Information Agency, Report No. 62, Interrogation of Albert Speer on "The Effects of Aerial Warfare and Allied Successes on German War Production" (interviewed on 6 September 1945), 8 November 1945, 5. During this interrogation, Speer provided copies of all the memos and other correspondence to which he referred.

³ MS16, S5, B12, F14, USSBS, *The United States Strategic Bombing Survey Summary Report (European War)*, 30 September 1945, 9.

⁴ Spaatz Box 273, USSTAF A-2, *The Contribution of Air Power to the Defeat of Germany*, Appendix E, The Attack on Enemy Oil Production and Distribution," 1 August 1945, 1.

of Germany's oil and fuel industries, which included consumption at a higher rate than the accumulation of stocks, and strategic reserves of 1.9 million tons at the start of the war compared to an annual consumption of 7.5 million tons. This meant the German oil position was entirely inadequate without constant replenishment from both German and outside sources, especially Rumania's Ploesti refineries. The German strategic reserve fell sharply in the last three months of 1939 and never again exceeded 1.5 million tons. Oil reserves increased with the victories of 1940, but the Reich was now responsible for the oil requirements of all the occupied countries and Italy, none of which could import oil due to the Allied naval blockade. Another key weakness was the concentration of fuel production at 26 large and vulnerable synthetic oil plants and crude oil refineries, which together produced 63 percent of the Reich's gasoline and 90 percent of its aviation fuel.⁵

Once they won air supremacy in the spring of 1944, the Allies turned immediately to a concerted attack on oil even as they engaged in two major transportation campaigns, first against the French and Belgian railroad networks in support of Overlord, and later against the Reich in an effort to undermine the German war economy. These campaigns were highly synergistic. As we have seen, heavy bombers pushed railheads far from the front lines, forcing the Germans to use truck convoys and, ironically, much more fuel as they made long and dangerous supply runs. Night-bombers and fighter-bombers singled out these convoys, along with fuel depots and fuel trains, in an effort to destroy as much fuel as possible. This was part of a larger effort to undermine German mobility and combat power with a concerted attack on *every facet* of oil and fuel production and

⁵ Ibid., 1-2; Ronald C. Cooke and Roy Conyers Nesbit, *Target: Hitler's Oil* (London: William Kimber, 1985), 17.

distribution. The oil and transportation offensives thus involved a concerted attack on Germany's most vital technology—the oil industry—in the broadest sense of the word. Air intelligence officers understood that *everything* having to do with oil, from its production to its transport and distribution at the fighting fronts, had to be attacked.

Indeed, as an MEW report noted, “No subject in the field of Germany’s economic war effort has received greater attention than her oil industry.”⁶ Moreover, this intelligence effort had from the outset been an inter-Departmental responsibility in which several British agencies, joined later by the Americans, met regularly to assess the German oil position. We have already seen how this process developed between 1939 and 1942. In March 1942 the Hankey Committee was disbanded and the Hartley Committee was placed under JIC (Joint Intelligence sub-Committee), renamed the Technical Sub-Committee on Axis Oil, and given responsibility for tracking the enemy’s oil position. This was approved by Churchill in a Minute still in force when the war ended. The Hartley Committee’s work was embodied in a series of semi-annual JIC reports on the enemy’s oil position, the last of which appeared in May 1944. A parallel Enemy Oil Committee was also set up in Washington D.C. and a combined conference held in July 1943 to arrive at a combined appreciation of the Axis oil position. With the start of the Oil Offensive in May 1944, the JIC’s Joint Anglo-American Oil Committee and its subordinate Joint Oil Targets Committee (JOTC) reviewed in detail each attack on enemy oil targets and promulgated prioritized target lists based on the success of the previous week’s raids and the operational status of each oil plant as well as its importance

⁶ AIR 8/1018, EAB (FO and MEW), “Intelligence on Enemy Oil Plants,” 3 January 1945, 1.

to the German war effort. In October 1944, these committees were subsumed by the Working Committee (Oil) of the Combined Strategic Targets Committee (CSTC).⁷

The CSTC Working Committee (Oil) had authority to co-opt technical experts as required and received regular assistance from two members of the U.S. Enemy Oil Committee; Lieutenant Colonel V. L. Forster of the Ministry of Fuel and Power; and civilian experts from Imperial Chemical Industries (ICI), the Shell Group, and several other civilian companies. The ACIU, and particularly Flight Lieutenant Kent of D (Industry) Section, one of the world's foremost oil experts and photointerpreters, also had the authority to call on these experts as needed. The Working Committee (Oil) of CSTC also provided assistance on demand to MAAF targeting and BDA experts. The JIC continued to publish its fortnightly reports on the effects of Allied attacks on German oil targets. This Anglo-American organizational machinery tracked German oil production with a high degree of accuracy and was thus able to determine the impacts, individually and in the aggregate, of Allied bombing raids on the Third Reich's oil position.⁸

In fact, ACIU photointerpreters had been studying the German oil industry intensely since 1940. Squadron Leader Hamshaw Thomas, in charge of D Section, led this effort to determine the capabilities and vulnerabilities of German oil plants and refineries. He began by visiting oil plants in Britain to learn all he could from their managers. When reconnaissance aircraft brought back the first photographs of the huge new synthetic oil plant at Leuna in the summer of 1941, Thomas traced all the processes involved in production, consulted again with the British experts, and put together a reliable system

⁷ AIR 8/1018, EAB (FO and MEW), "Intelligence on Enemy Oil Plants," Annex to report: "Inter-Departmental Machinery for the Appreciation of Oil Intelligence," 3 January 1945, 1.

⁸ Ibid., 1-2;

for estimating the maximum productive capacity of a synthetic oil plant from the interpretation of its various units. Then coverage of Brůx in the Sudetenland in early May 1942 confirmed that a huge new synthetic oil plant was under construction there. Flight Lieutenant Peter Kent, a young and exceptionally capable oil geologist who Hamshaw Thomas had just put in charge of interpreting oil plants, employed this and many subsequent photos to collect crucial information on the German oil industry. Kent soon had six interpreters helping him, including two Americans. Together with other intelligence agencies, Kent and his team made possible the detailed planning for the oil offensive, which began in May 1944.⁹

Once sustained bombing of oil targets began on 12 May 1944, Kent and his team kept a board in their office estimating the operational status of each plant, dates for reconnaissance aircraft to re-photograph each plant, dates of return to production, and timing for follow-on raids. Kent and his team guided bombers to the most important targets by helping the JOTC and later the CSTC Working Committee (Oil) to build very effective weekly target lists.¹⁰

These successes rested on the foundation provided by a mature reconnaissance capability, which kept a close eye on the sources of German oil production. These included synthetic oil plants, crude oil fields and refineries, and benzol plants. With abundant photos in hand, ACIU photointerpreters uncovered every oil target in the Reich and occupied Europe. These included two oilfields in the Vienna basin and others in Germany, Hungary, and Czechoslovakia. The discovery of the huge plant at Brůx and a

⁹ Babington Smith, *Evidence in Camera*, 170-172.

¹⁰ Cooke and Nesbit, *Target: Hitler's Oil*, 11-12, 15.

second large plant at Blechhammer also proved vital to the success of the oil offensive. In short, reconnaissance photos, ACIU interpreters, and targeting committees (the JOTC and CSTC) gave senior airmen the insights they needed to destroy Germany's oil industry. Consequently, the quantity of finished POL products refined from crude oil decreased from 697,000 tons per month in April 1944 to 33,000 tons per month in April 1945. The quantity of finished petroleum products from synthetic oil plants decreased from 480,000 tons to 16,000 tons per month. These figures equaled 4.5 and 3 percent, respectively, of pre-attack production of POL products made from crude and synthetic oil.¹¹

The reconnaissance effort against German oil production got into high gear in 1941 with extensive cover of new synthetic oil plants. The Bergius plant at Leuna first came under a Spitfire's cameras on 13 July 1941. The cover showed 18 high-pressure coal-conversion cylinders, each capable of producing 22,000 tons of oil per year, for an annual total of 396,000 tons. A follow-up sortie noted a second plant being built at Leuna, which would nearly double the annual output.¹² Another key discovery followed as the first cover of a huge plant at Pölitz arrived at the ACIU on 13 September.¹³ Pölitz soon became the Third Reich's leading producer of aviation fuel and thus came under heavy attack during the oil offensive. Gelsenkirchen was first photographed in December 1940. Photointerpreters estimated its annual output for 1941 and 1942 at 250,000 tons per year and for 1943 at 350,000 tons.¹⁴ Reports followed quickly for Magdeburg, Lützkendorf,

¹¹ AIR 40/1816, Air Ministry, *Photographic Intelligence during the European War*, 30 June 1945, 19-20.

¹² AIR 34/199, CIU, Detailed Interpretation Report No. 1905 (D), "Schkopau-Leuna-Merseberg," 18 July 1941, 1-4; AIR 34/200, CIU, Interpretation Report No. D.92., "Merseberg/Leuna," 30 April 1942, 1-2.

¹³ AIR 34/199, CIU, Industry Interpretation Report No. D.13., "Pölitz," 2 October 1941; AIR 34/627, ACIU, Industry Interpretation Report No. D. 57., "Pölitz Synthetic Oil Plant," 21 January 1942.

¹⁴ AIR 34/200, CIU, Interpretation Report No. D86., Gelsenkirchen Synthetic Oil Plant, 19 April 1942, 1-5.

and Zeitz, which together produced nearly a million tons of fuel per year.¹⁵ Even more vital was the discovery of Brück, the Reich's largest oil plant, in May 1942.

Brück was one of those instances in which mundane sources—in this case advertisements for workers in Prague newspapers and petroleum engineers in German engineering journals—tipped off the British. The reconnaissance sortie they sent to investigate discovered the plant. Its 15 coal-conversion stalls could each produce 50,000 tons of oil a year; an annual output of 750,000 tons. Two of these were complete within two months, providing an initial output of 100,000 tons a year. During the next two years, reconnaissance confirmed the Germans had added further stalls. By summer 1944 Brück would have produced 1,250,000 tons of oil a year had Allied bombers not rendered it inoperative in spring 1944 and kept it that way until VE Day.¹⁶

Another report on the Fischer-Tropsch plant at Sterkrade-Holten described the plant's key features and described the main features of the Fischer-Tropsch process.¹⁷ The key difference between Fischer-Tropsch and Bergius plants was that the former used hard (black) coal and the latter used soft (brown) coal. The Bergius process was also more efficient and produced higher grades of fuel, making Bergius plants the primary producers of aviation fuel. The new Bergius and Fischer-Tropsch Plants coming on line between 1941 and 1944 represented a major increase in oil production and promised, along with deliveries from Ploesti, to make the German oil position secure. Had the

¹⁵ AIR 34/200, CIU, Interpretation Report No. D.89., "Lützkendorf Synthetic Oil Plant," 25 April 1942; AIR 34/200, CIU, Interpretation Report No. D.94., "Zeitz/Troglitz Synthetic Oil Plant," 30 April 1942, 1-4; AIR 34/200, CIU, Interpretation Report No. D.93., "Magdeburg Synthetic Oil Plant," 1 May 1942, 1-2.

¹⁶ AIR 34/200, CIU, Interpretation Report No. D.100., "Brück Synthetic Oil Plant," 10 May 1942, 1-4; AIR 40/1816, Air Ministry, *Photographic Intelligence during the European War*, 30 June 1945, 14-15.

¹⁷ AIR 34/200, CIU, Interpretation Report No. D. 112., "Description of Fischer-Tropsch process as noted at Sterkrade-Holten," 9 June 1942, 1-9.

Germans conquered the Caucasus oilfields, their position would have been strong indeed. The fact that they did not do so, when combined with the huge demands for fuel brought on by a three-front war and the severe damage caused by the oil offensive, spelled disaster for German armies and air forces in the field.

In 1941 and 1942, however, this triple disaster seemed unlikely. At first glance, then, it seems surprising that the British started photographing German oil plants and refineries nearly four years prior to the start of the oil offensive. If we recall, however, their faith that eventually they would have enough bombers to go after the Third Reich's oil assets, this proactive effort becomes easier to understand. It would pay huge dividends for the Allied war effort.

One of these reports, from January 1942, noted that the Russian campaign had already reduced German oil stocks from 5,000,000 to 3,000,000 barrels, nearly half of which was effectively unusable because it was stuck in pipelines, in refining equipment, or on supply trains. An increasing use of substitute fuels indicated a worsening oil shortage. The report concluded:

In general, therefore, it seems that our general estimates are correct and that the Germans will enter the campaigning season of 1942 with only a fraction of the oil reserves they have previously had, reserves so low in fact that their strategy in 1942 must be conditioned by the need to obtain a further supply of oil.¹⁸

At the same time, Russian officers pressed the British to attack oil plants, an indication that they, too, recognized the stringency of Germany's oil position. The Secretary of State for Air, Sir Archibald Sinclair, was impressed enough to press Portal, yet again, for

¹⁸ AIR 8/1016, DDI3, "German Oil Position, January 1942," 21 January 1942, 1-2.

an attack on oil.¹⁹ Portal fired back, noting that MEW believed only a concerted attack on *both* Germany's synthetic oil plants and the crude oil refineries at Ploesti could achieve decisive effects. Bomber Command could not yet accomplish such a task. The matter rested there for the next two years.²⁰

In July 1942, a committee of 12 oil experts from six civilian oil companies, the Air Ministry, the ACIU, and MEW arrived at similar conclusions, stating that denying either the production of 12 Bergius plants or the fuel from Ploesti would cause major problems for the German war effort, while denial of both could be decisive. The committee also estimated that Germany and its allies were producing about 15,000,000 tons per year of finished POL products, a figure that proved extremely accurate when compared later with captured German and Rumanian records.²¹

By the end of the year, however, the picture was less rosy. A JIC report noted that although Germany's strategic reserve was largely depleted and her oil position precarious for the moment, by the middle of 1943 several new oil plants would come on line, resulting in another 1,000,000 tons of fuel per year. The report cautioned that output would increase even further in 1944.²² Despite this concern, a report produced four days later noted that the increasing scale and scope of Allied operations was placing an enormous strain on the Reich's oil position. If the Allies succeeded in opening new fighting fronts in Italy and France, and if their bombers could attack Ploesti and German

¹⁹ AIR 8/1016, Minute, Sinclair to Portal, 2 February 1942.

²⁰ AIR 8/1016, Minute, Portal to Sinclair, 13 February 1942.

²¹ Spaatz Box 59, MEW and Air Ministry, "The Oil Supply Position in Axis Europe," 1 July 1942, 1-2.

²² AIR 8/1017, JIC (42) 487, War Cabinet, Technical Sub-Committee on Axis Oil, "The Axis Oil Position in Europe November 1942 (Interim Report)," 12 December 1942, 1-6.

oil plants, the picture might become bleak for Germany. "Stocks of oil in Axis Europe have fallen so low," it said, "and the stringency of the Axis oil position is such that:

(a) any action that can be taken by the United Nations which will result in forcing the Axis substantially to increase the consumption of oil during the coming winter may vitally limit Germany's strategic capabilities; (b) the effect of the removal of even a relatively small source of oil supply has now become out of all proportion to the intrinsic importance of the source itself. Therefore, the destruction of any of the synthetic oil plants may give a valuable dividend; and (c) a crippling blow will be struck at the enemy's capacity to continue the war if and when it becomes possible to interrupt the Roumanian source of supply or the means by which oil supplies from Roumania are transported to Germany.²³

There was, in other words, absolutely no "slack" in the German oil position. A

Combined Chiefs of Staff report to Roosevelt and Churchill made them aware of this:

We have taken note that the Axis oil situation is so restricted that it is decidedly advantageous that bombing attacks on the sources of oil, namely the Rumanian oil fields and oil traffic on the Danube, and the synthetic and producer gas plants in Germany, be undertaken as soon as other commitments allow.²⁴

Additional reports followed, making clear the increasingly strained German oil position. A JIC report cautioned that with the 1,000,000 barrels of oil per year previously given to Italy now back in German hands, the Third Reich's oil production from November 1942 through April 1943 exceeded consumption by 500,000-600,000 barrels.²⁵ However, the great tank battle of Kursk, followed by a Russian offensive, erased these gains and again made Germany's oil situation precarious. The Allied invasion of Italy and the huge battle for air supremacy in the skies over the Reich also contributed to the gradual depletion of German fuel stocks.²⁶

²³ AIR 8/1017, JIC (42) 487, "Axis Oil Position in Europe, November 1942," 16 December 1942, 1-2.

²⁴ AIR 8/1017, 1279, CCS Extract: Axis Oil Position Worsening, CCS to Roosevelt and Churchill, 23 January 1943.

²⁵ AIR 8/1017, JIC (43) 340, "The Axis Oil Position," Annex B, 18 August 1943, 1-7.

²⁶ AIR 40/2073, Order from Luftgau South, 12 August 1943; AIR 40/2073, Order from OKW, 11 September 1943.

By the end of 1943, a JIC report emphasized that the Germans had failed to bring new oil plants on line as quickly as predicted, while Allied offensives had taken a serious toll on German fuel reserves. Even more ominous for Germany, Allied air bases in Italy were now in range of Ploesti and other key refineries and oil plants in central and eastern Europe.²⁷ General Spaatz, soon to command USSTAF, and his Director of Intelligence (A-2), Brigadier General George McDonald, sensed that once the USAAF had won air supremacy, oil had to be the key target set. In the plan he submitted for the completion of the Combined Bomber Offensive, Spaatz pushed for an all-out attack on oil to undermine the combat power of German forces *on all fighting fronts*.²⁸ So, too, did Air Commodore Sidney Bufton, the Air Ministry's Director of Bomber Operations, who argued that

The denial of the bulk of his oil supplies would make it impossible for the enemy to sustain his present scale of military operations on the Russian and Italian fronts and at the same time to deploy his maximum effort for the repulse of 'OVERLORD'...²⁹

Bufton also recommended oil attacks as a means for defeating the Luftwaffe "at both ends"—by killing pilots in the air as they defended Germany's vital oil installations, and by robbing the Luftwaffe of fuel to train and operate in the skies over the Reich.

Although Eisenhower, who had operational control of heavy bombers from 15 April to 15 September, chose the Tedder-Zuckerman transportation plan as the primary means for providing support to Overlord, he also saw the utility of an oil offensive and approved it as well. Portal, too, saw its merits, as did the Combined Chiefs of Staff, Roosevelt, and

²⁷ AIR 8/1017, JIC (43) 480, "The Axis Oil Position in Europe," 26 November 1943, 1, 4.

²⁸ Spaatz Box 144, USSTAF, "Plan for the Completion of the Combined Bomber Offensive," 5 March 1944, cover memo and 1-3. Emphasis added.

²⁹ Spaatz Box 114, Air Ministry, DBOps, "Note on the Employment of the Strategic Bomber Forces Prior to Overlord," 19 March 1944, 5.

Churchill. The first hard blows of this crucial air campaign would fall not on Germany, but on Rumania.

10.2 Oil Attacks Begin: Mediterranean Allied Air Forces Raids on Ploesti

Allied airmen had long sought to go after Ploesti in a concerted fashion. The 11 major crude oil refineries near this town provided Germany with 1.5 million tons per year of POL products, including 30 percent of Germany's oil and 30 percent of her motor and aviation fuel. They therefore comprised the central targets for Mediterranean Allied Air Forces (MAAF) bombers.³⁰ The first effort against Ploesti, a low-level attack by 9th Air Force B-24 heavy bombers, had actually occurred eight months earlier, on 1 August 1943. Although the Americans suffered heavy losses, they did severe damage to several refineries, decreasing annual refining capacity from 9,235,000 to 5,300,000 tons—a 42.5 percent decline.³¹ Luftwaffe *Generalleutnant* Alfred Gesternberg, in charge of Ploesti's air defenses, had built a ring pipeline that allowed the Rumanians to move crude oil from damaged to operational refineries, but he could not convince the Rumanians to repair all of their refineries.³² Because they had excess refining capacity, the Rumanians viewed this as a waste of effort.³³ Instead, they wrote off two refineries, reducing their annual refining capacity to 8,000,000 tons.³⁴ Nor did they build protective concrete walls

³⁰ Cooke and Nesbit, *Target: Hitler's Oil*, 78-79; Spaatz Box 95, HQ MAAF, "Air Power in the Mediterranean: November 1942-February 1945," 13 February 1945, 39.

³¹ Aleksandar Milutinovic, "First Foray: The United States Army Air Forces' Strategic Strike at Ploesti, 1 August, 1943," unpublished M.A. Thesis, The Ohio State University, 2001, 155-156. The BDA reports for this raid are at RG341, E217, B62 and RG 341, E217, B71. They include CIU Photographic Interpretation Reports Nos. 3291 (3 August 1943), 3292 (3 August), 3294 (5 August), and 3339 (12 August), produced by the Middle East Interpretation Unit.

³² Cooke and Nesbit, *Target: Hitler's Oil*, 86-87.

³³ Milutinovic, "First Foray," 158.

³⁴ Spaatz Box 95, HQ MAAF, "Air Power in the Mediterranean: November 1942-February 1945," 13 February 1945, 39-40. The Rumanians were only producing 4.8 million tons of petroleum products per

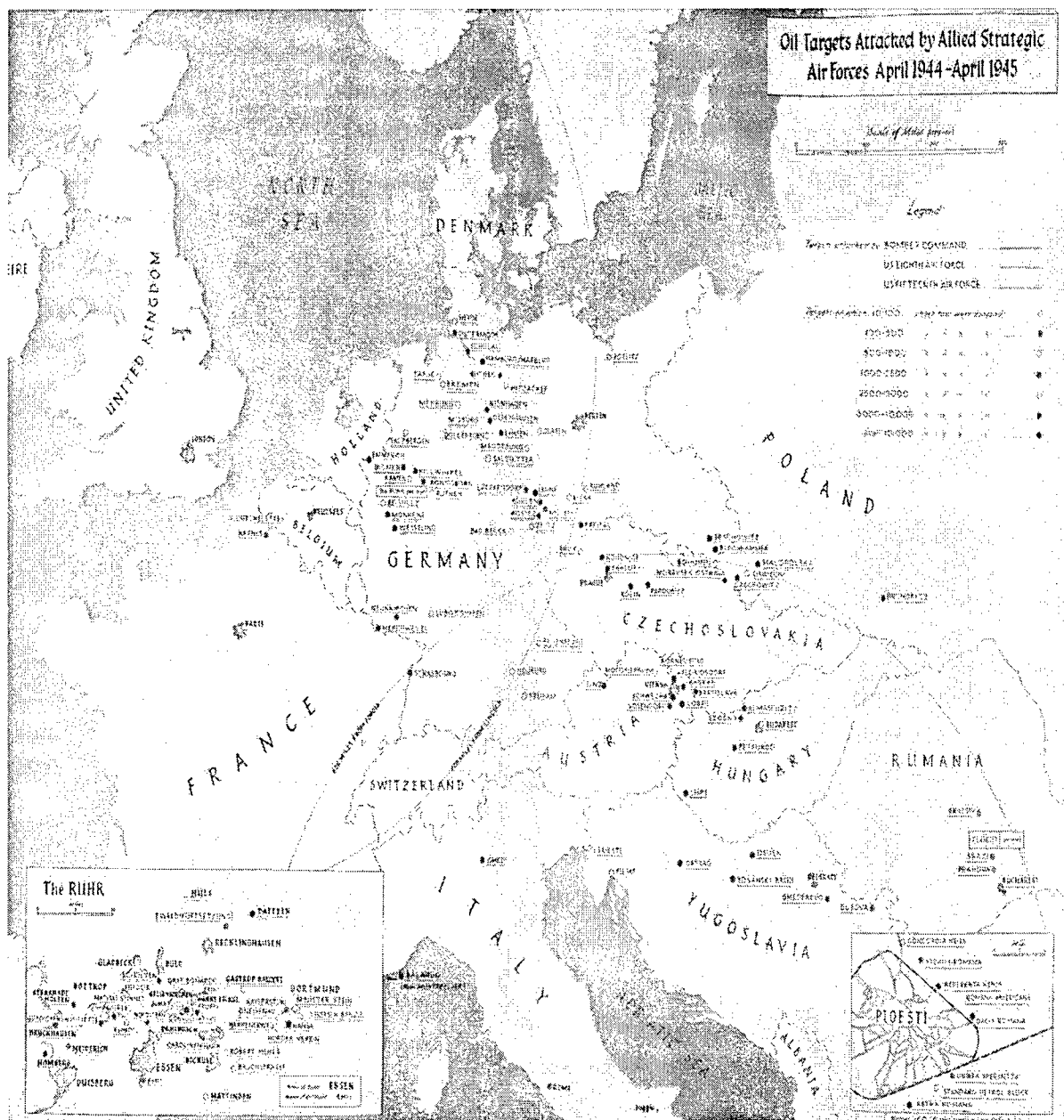


Figure 10.1: Oil Targets in Germany and Occupied Europe

Source: Sir Charles Webster and Noble Frankland, *The Strategic Air Offensive against Germany, 1939-1945, Volume III, Victory* (London: Her Majesty's Stationery Office, 1961), Map 1, 47.

year when the MAAF air offensive began, so objective was to reduce fuel production as far below that figure as possible.

around key equipment and storage tanks. Consequently, the MAAF campaign against Ploesti from April through August 1944 had a rapid and severe impact on oil production.

An increase in Rumanian oil deliveries to Germany as of November 1943 made clear that production, despite the impacts of the 1 August 1943 raid, was back on track, although it now took nearly all of Rumania's refining capacity to meet Germany's incessant and increasing demands. One development of particular note was the increase of oil shipments on the Danube River from 2,260 tons in November 1943 to 3,850 tons in December. This required 14.7 oil trains per day, each with 30 cars holding 13.6 tons of oil per car, unloading at Giurgui.³⁵ These increased shipments made a bombing campaign against Ploesti urgent. Spaatz and Lieutenant General Ira Eaker, the MAAF commander, pushed hard for authority to launch such an effort. Yet they did not receive a go-ahead from the Combined Chiefs of Staff to mine the Danube until early April, and it took nearly two months more to receive permission to attack Ploesti, although, in an act of calculated insubordination, they ordered the first raids on Ploesti's refineries in early April. In fact, two weeks *before* the Chiefs of Staff gave the go-ahead, Eaker told Spaatz that "We mean to *finish off this job* in the Ploesti area with the first favorable weather."³⁶

³⁵ Spaatz Box 187, OSS, Report No. SQ. 590, "Rumania: Economic, Oil Production, Transport, etc.," 12 January 1944, 2.

³⁶ See AIR 8/1332, which contains 19 cables, memos, and Minutes dealing with this issue. The Allied focus in early 1944 was first and foremost an effort to knock Bulgaria out of the war by bombing Sofia, which did not succeed, and secondarily the interdiction of Rumanian marshalling yards to assist with the planned Russian summer offensive by starving German and Rumanian troops in southern Russia of fuel and other supplies. Eaker and his staff simply began bombing oil targets in April 1944 while seeking official sanction to do so from the Combined Chiefs of Staff, which they received on 30 May, nearly two months into the *de facto* campaign against Ploesti's oil refineries. The cables in question were COSMED 117, 30 May 1944, which gave Ploesti oil targets second priority after marshalling yards, and COSMED 124 of 6 June 1944, which made the oil refineries MAAF's primary target set. Eaker's comments are at Spaatz Box 17, in the cover memo for a report entitled "Result of Attacks on Axis Oil Installations," produced on 15 May 1944. Emphasis added.

Once they had permission to proceed with aerial mining of the Danube, the MAAF Strategic Targets Committee quickly exploited the vulnerabilities of Rumania's oil-shipping activities, including the rail-to-barge transshipment process and the barges themselves, the former with bombing raids and the latter with aerial mining. By late April 1944, aerial mining of the Danube had caused severe transport difficulties because the Germans and Rumanians lacked the proper equipment to sweep the advanced acoustic mines dropped by Allied bombers.³⁷ Once the Ploesti campaign ended, USAAF and RAF ground survey team went to Rumania to study the bombing campaign. During a conference with the Director of Commercial Marine, a major shipping company, and a tugboat pilot familiar with Upper Danube, they learned that the effects of aerial mining before Rumanian defection to the Allies had been significant, with more than 200 barges and 60-70 tugboats sunk. In addition, one of Belgrade's bridges was destroyed by bombing and collapsed into the river, halting traffic for two weeks. After the Rumanian defection, Rumanian artillery and gunboats destroyed over 100 German boats, while the Germans themselves sank several of their own boats to block river navigation by the Allies. These developments caused a major decrease in oil shipments up the Danube. Albert Speer noted in a postwar interrogation that the mining of the Danube had been even more harmful than attacks on Ploesti's refineries.³⁸

As the mining of the Danube took its toll on barge traffic, MAAF attacks on Ploesti got into high gear. With air superiority over Rumania secured during earlier attacks on marshalling yards, MAAF heavy bombers flew a total of 20 missions against Ploesti from

³⁷ MS16, S5, B12, F4, HQ SHAEF, "Commanders Weekly Intelligence Review No. 4," 30 April 1944, 1.

³⁸ RG243, E31, B1, "USSBS Interview No. 11, Subject: Reichsminister Albert Speer, 31 May 1945, Minutes of a 19 May 1945 interrogation, 9.

5 April through 19 August. These attacks destroyed 89 percent of Ploesti's productive capacity (from 709,000 tons per month to 77,000 tons) and reduced its gasoline and aviation fuel output by 91 percent (from 177,000 tons per month to 15,400 tons). This was highly significant because Rumania supplied one-third of Germany's gasoline and aviation fuel prior to these attacks, most of which went directly to the Eastern Front. In combination with continuing transportation attacks, which made the movement of oil, ammunition, and reinforcements difficult, this resulted in major operational problems for German forces in southern Russia and contributed to the rapid Soviet advance as well as the collapse of German resistance in southern Russia and the Balkans.³⁹ During this campaign, MAAF bombers flew 6,186 sorties and dropped 13,469 tons of bombs.⁴⁰

Following what had now become standard operating procedure, Eaker sent a ground survey team to Ploesti immediately after the Russians captured it. Both Arnold and Spaatz emphasized the importance of this 10-man team's work. The team, comprised of American and British BDA experts under the authority of the British Bombing Survey Unit, sought to determine bombing effects and effectiveness. To do so, they compared

³⁹ Dr. B. G. Hopper, the USSTAF Historian, related an amusing but instructive anecdote about the effects of these attacks on German resistance. "Even the Russians," he said, "who were at first unimpressed by the strategic air offensive as an equivalent for the ground battle, have followed the campaign with rapt attention and constantly urge the airmen on. Russian ground troops who occupied Rumania were awed by the amount of wreckage left by strategic bombing, and American airmen tell of Russian officers, knowing only a few English words, who would seize their hand, shout 'Ploesti—good, very good,' and beam their unqualified admiration." Hopper was probably referring to meetings between members of the Anglo-American BDA ground-survey team, sent to Ploesti immediately after its capture, and their Red Army hosts. See Spaatz Box 202, Draft History of Oil-versus-Transportation Debate (no title), and Cover memo from Colonel Maxwell to Dr. B. G. Hopper, Historical Section, HQ USSTAF, 2 November 1944, 25.

⁴⁰ RG243, E36, B200, Mediterranean Allied Strategic Air Forces (MASAF), "Ploesti: Summary of Operations Results and Tactical Problems Involved in 24 Attacks between 5 April and 19 August 1944," September 1944, 1-2; Spaatz Box 95, HQ MAAF, "Air Power in the Mediterranean: November 1942-February 1945," 13 February 1945, 40-41; Mediterranean Allied Photo Reconnaissance Wing (MAPRW), Interpretation Report No. D153., 22 May 1944, 2-9. The MAPRW report noted 60 specific components and buildings damaged in the six major raids between 5 April and 18 May, including direct hits on several distillation, cracking, and power plants that shut down individual refineries permanently or for weeks.

BDA during the campaign with Rumanian damage records and then provided detailed reports facilitating the same iterative learning process that had occurred in the transportation campaigns against the Italian and French railroads. The team's key report noted that estimates of lost production during the campaign had been accurate, but that most of the lost production and throughput had been caused by general damage from the high weight of attack brought to bear on the refineries, not from hits on vital components. The team further noted that modern refineries were extremely flexible and could simplify their refining procedures and decrease the quality of their product even when vital components were heavily damaged. Consequently, the notion of shutting down a refinery by damaging its vital components should be abandoned. Instead, aircrews should try for the greatest concentration of hits on the refinery by placing their aimpoints at the center of the installation. Equally important was the team's discovery that fire did much greater damage than blast even in refineries shut down before they were bombed. Similarly, bombs exploding on or just above the surface of the ground caused greater damage than those which detonated beneath the surface. Fragmentation was also more effective than blast because bomb fragments tended to ignite spilled fuel and oil.⁴¹

The team made five key recommendations put into practice during subsequent bombing operations. The first was to stop MAAF's bad habit of sending heavy bombers over their targets at the same time of day, a comment we might have expected in an assessment of Linebacker II but not during the final year of the Second World War, when Allied tactics were supposedly at their best. The second was to attack with mixed bomb

⁴¹ Eaker B I:27, F9, Memo, Eaker to General Wilson (AFHQ), "Request for Authority to send a Bomb Evaluation Unit to Ploesti" 29 August 1944; AIR 2/8011, British Bombing Survey Unit (BBSU), "Preliminary Conclusions upon the Effects of the Air Bombardment of the Roumanian Oil Refineries," 8 November 1944, 1-2.

loads designed to cause maximum damage while causing the greatest possible delay in repair efforts. This meant 500-lb. bombs with instantaneous tail fusing or a 0.01 second delay for highly congested refineries, incendiaries to ignite fires, and delay-fused bombs to keep repair crews at bay. The third was to achieve surprise and catch plants up and running to maximize damage. Fourth, attempts to exhaust smoke screens by putting larger bomber formations and longer bomber streams over the target had a good chance of success, but the decision to do so depended on the strength of enemy defenses. Fifth, the team said a "continuity of offensive [operations] is essential."⁴² This simply meant that oil campaigns had to be pressed home over a period of months with a heavy weight of attack. Allied airmen changed tactics and weapons accordingly as attacks continued.

In addition to the Ploesti raids, MAAF was tasked to destroy 46 crude oil refineries and five synthetic oil plants in southern Germany, Austria, Hungary, Czechoslovakia, and Poland. These targets produced about 60 percent of all German petroleum products.⁴³ The Mediterranean Oil Targets Intelligence Committee provided target priority recommendations for these installations, based on the most current BDA reports from the Mediterranean Allied Photographic Reconnaissance Wing, to the JOTC and later the CSTC Working Committee (Oil) in advance of their weekly meetings so they could determine attack priorities for *all* German oil targets.⁴⁴ These included synthetic oil plants in the Ruhr and central Germany, all of which came under heavy and concerted attack by 8th Air Force and Bomber Command on 12 May 1944.

⁴² Ibid., 3.

⁴³ Spaatz Box 95, HQ MAAF, "Air Power in the Mediterranean: November 1942- February 1945," 13 February 1945, 39.

⁴⁴ See, for instance, MS16, S3, B4, F1, MAAF to USSTAF, "Weekly Oil Summary," third report, 29 July 1944.

10.3 The Campaign Intensifies: BDA and Raids on German Oil Plants

The first major attack on synthetic oil plants in the Reich took place on 12 May 1944, when 15 of 8th Air Force's bomb wings totaling 886 heavy bombers, escorted by 21 fighter groups (576 aircraft) attacked Leuna, Lützenkendorf, Zeitz, Böhlen, Brück, and the Zwickau aircraft components plant in clear weather. The crews conducted visual bombing attacks with good results, dropping 1,718 tons of bombs. Photointerpreters at bomb groups determined from strike photos that results were very good at Brück, where bombs seriously damaged the gas-generating plant, boiler house, oil storage tanks, and gas-purification plant. Böhlen also suffered heavily, with several hits on the gas generating plant and refinery, boiler house, condensing tower, and power plant. Zeitz sustained at least 12 hits on the gas-generating plant, three on the purification and conversion plant, one on the injector house (with another near miss), and several hits on the power plant. Damage to Leuna was good, with large fires visible in the hydrogen contact houses and numerous other buildings throughout the plant. The results at Lützenkendorf were fair, with the Fischer-Tropsch gas-condensation building, the contact-oven house, and power plant all hit. Based on what photointerpreters knew about synthetic oil plants, the hits scored on these key components ensured that these five plants would be out of action for at least four weeks.⁴⁵

Four days after this opening round of oil attacks, McDonald contacted Dewdney at RE8 request damage assessments. He sent copies of the memo to 8th Air Force ORS, the Enemy Objectives Unit, and the 19th Photographic Interpretation Detachment at RAF

⁴⁵ AIR 40/626, "Eighth Air Force Narrative of Operations, 353rd Operation, 12 May 1944," 13 May 1944, 1-2.

Pinetree, indicating that he expected BDA experts there to collaborate in the production process, which by now was the norm. The 19th PID had provided damage assessments for RE8's detailed studies since late 1942, and analysts there relied in turn on ACIU K and D reports.⁴⁶ By early June the reports were ready. Each began with the caveat that

Until more evidence is available on the enemy's ability to repair these plants, only provisional reports will be issued with limited circulation. The course of repair depends on the availability of specialized labour and materials about which too little is yet known to permit firm estimates. Final reports will be issued as soon as our information warrants it.⁴⁷

This underscored the fact that bombers had previously engaged in too few attacks on oil plants to provide an understanding of how quickly the Germans could make repairs. As the ACIU and RE8 soon discovered, they proved capable and often had plants repaired well in advance of estimates. Ultimately, however, they could not keep pace with attacks, which occurred just before or shortly after each plant was put back in service.

The assessment for Brück , based on USAAF 7th Group reconnaissance photographs taken 1.5 hours and 17 days after the raid, showed a loss of seven weeks' output—about 95,000 tons of synthetic oil. An assessment of damage to key components showed direct hits on the gas plant, where one of five Winkler generators was destroyed and another two damaged; three hits on the power plant; two hits on the blower house; two of five gas holders destroyed and two moderately damaged; and severe damage to the distillation unit's main pipe works. Full production could resume in 3-4 months. The plant was still completely inactive 17 days after the raid.⁴⁸

⁴⁶ Spaatz Box 137, Memo, Surbeck (Anderson's assistant) to Dewdney, 16 May 1944, 1-2.

⁴⁷ See, for instance, HO 191/118, RE8, "Provisional Attack Assessment Report, Sudetenlandische Treibstoffwerke A.G., Brück, Sudetenland, Synthetic Oil Plant, Attack of 12th May 1944," 7 June 1944, 1.

⁴⁸ HO 191/118, RE8, "Provisional Attack Assessment Report, Sudetenlandische Treibstoffwerke A.G., Brück, Sudetenland, Synthetic Oil Plant, Attack of 12th May 1944," 7 June 1944, 1-3.

The raid on Böhlen also caused severe damage, with a loss of 10 weeks' production—about 65,000 tons of oil. Direct hits on the power plant and local electricity grid also resulted in a loss of about 45,000 kilowatts to the German electric grid. Full pre-attack production would not resume until 3-4 months after attack.⁴⁹

The plant at Zeitz took the hardest hammering of all, with "severe general damage" causing a loss of about 16 weeks' output, or 120,000 tons of oil. The plant would be shut down for 10 weeks and at working at 80 percent of capacity within 5 months. During a second attack in late May "the whole plant was blanketed by a dense concentration of bombs, and damage was done to almost every unit in the plant." The boiler house and generator hall took 2-3 hits, putting the plant out of action for at least three months.⁵⁰

Leuna, although less severely damaged than the other plants, nonetheless lost 6-10 weeks' synthetic oil production. All seven boiler houses and four of five compressor houses received hits, putting the plant entirely out of action for at least a month and at 50 percent of pre-attack production for a second month—a loss of about 82,000 tons of oil.⁵¹

In addition to these initial reports, RE8 analysts produced a steady stream of assessments for every oil attack. The first of these was an assessment of the 28 May attack on Ruhland Fischer-Tropsch plant, which resulted in a loss of 3-4 weeks' output, or 20,000 to 30,000 tons of oil. Analysts noted that the plant would be back at 90 percent

⁴⁹ HO 191/118, RE8, "Provisional Attack Assessment Report, Braunkohle-Benzin A.G. Synthetic Oil Plant and Sächsische Werke A.G. Power Plant and Gas Works, Böhlen, Germany, Attack of 12th May 1944," 7 June 1944, 1-3.

⁵⁰ HO 191/119, RE8, "Provisional Attack Assessment Report: Braunkohle-Benzin A.G. Synthetic Oil Plant, Tröglitz/Zeitz, Germany, Attacks of 12th and 28th May, 1944," 22 June 1944.

⁵¹ HO 191/118, RE8, "Provisional Attack Assessment Report: I. G. Farbenindustrie Synthetic Oil Plant, Merseberg/Leuna, Germany, Attack of 12th May 1944," 7 June 1944, 1-3.

of pre-attack production in a month. Nonetheless, this raid alone reduced the plant's annual output by between 5.7 and 8.6 percent.⁵²

A 28 May raid on Pölitz caused serious damage, with hits on the injector-circulator house and other key components resulting in a loss of six weeks' output, or 70,000 tons of oil. As the assessment noted, Pölitz was "extremely flexible and is able to handle a wide variety of feed stocks, including natural petroleum crude." It also produced 100,000 tons per month of aviation fuel, making it a crucial target in Spaatz's view.⁵³

Albert Speer, who knew as well as anybody what the oil offensive portended, wrote to the Führer and his military staff on 30 May. His warning was blunt and urgent:

With the attacks on the hydrogenation plants, systematic raids on economic targets have started at the most dangerous point. The only hope is that the enemy has also got an Air Staff! Only if the latter had as little comprehension of economic targets as the German one would there be some hope that after a few attacks on this decisive economic target it would turn its attentions elsewhere.⁵⁴

Speer's acerbic quip about the Luftwaffe's Air Staff aside, he knew that oil attacks targeted, as he put it, "the most dangerous point" in the German war effort. On 17 June, he sent a desperate plea for assistance with repair efforts to *Reichsminister* of Finance Schwer-Krosick, Chief of Labor Hierl, and *Reichsführer* Himmler requesting the transfer of all electro-technicians, pipe-layers, and welders from the police, labor service, and Frontier Customs Guard to repair damage to oil plants. "The situation," he said, "is so urgent and serious that, without your help, it will not be possible for me to repair the

⁵² HO 191/118, RE8, "Provisional Attack Assessment Report: Braunkohle-Benzin A.G. Synthetic Oil Plant, Ruhland, Germany, Attack of 28th May, 1944," 27 June 1944.

⁵³ HO 191/118, RE8, "Provisional Attack Assessment Report: Hydrierwerke Pölitz A.G. Synthetic Oil Plant, Pölitz, Germany, Attack of 29th May, 1944," 27 June 1944, 1-3.

⁵⁴ AIR 20/8780, Control Commission for Germany (BZ), Field Information Agency, Report No. 62, Interrogation of Albert Speer on "The Effects of Aerial Warfare and Allied Successes on German War Production" (interviewed on 6 September 1945), 8 November 1945, 5. During this interrogation, Speer provided copies of all the memos and other correspondence to which he referred.

Hydrogenation Plants, upon whose speedy reopening depends, to a high degree, the continuation of the war.”⁵⁵

The most spectacular success in this opening phase of the oil campaign went not to the 8th Air Force, which carried out all the attacks just reviewed, but to Bomber Command, whose 12-13 June night attack on the Gelsenkirchen-Nordstern Bergius plant caused severe damage. The estimated production loss was six months’ output totaling 200,000 tons of synthetic oil, including a loss of 1,000 tons (240,000 gallons) of aviation fuel per day for an indefinite period, which, along with similar results at Pölit, represented an impending operational catastrophe for the Luftwaffe. The report stated that a resumption of pre-attack production, if achievable at all, not likely before December 1945. A key reason for this success was the superb accuracy resulting from expert Pathfinder Force work with improved Oboe sets that allowed Pathfinder Mosquitoes to drop flares at precisely the right locations. The 286 Lancasters of the main force then dropped 1,500 of their 4,637 bombs—over 32 percent of all munitions—directly on the oil plant. The fact that 320 of these bombs were 4,000-lb. “Blockbusters” proved highly significant because they caused severe structural damage and smashed both buried electrical and water conduits as well as overhead steam pipes, creating a nightmarish situation for repair crews. These British raids put a much greater weight of bombs on their targets than did 8th Air Force missions because Lancasters carried 14,000 pounds of bombs and B-17s only 6,000-9,000 pounds. The fact that British bombers attacked their targets in trail and individually rather than in combat boxes, which bombed in unison, also meant a heavier concentration of hits around the aimpoint. These Bomber

⁵⁵ Ibid.

Command advantages translated into greater accuracy and much more severe damage. The trick would be getting Harris to send his bombers after this "panacea target" rather than cities. Portal eventually brought him into line, as we will see, and the result was a spectacularly successful series of Bomber Command night precision attacks *beyond* the range of Oboe from December 1944 to February 1945. In the meantime, the Gelsenkirchen raid showed just how severely Bomber Command heavies could damage Germany's synthetic oil plants. The plant had produced 400,000 tons of oil per year since its completion in March 1941; it would produce no more after this raid.⁵⁶

As this first phase of the oil offensive against Germany and the MAAF campaign against Ploesti got into high gear, a delegation of American senior officers visited their counterparts in the Soviet Union from 10 to 15 May to discuss, among other things, how the heavy-bomber force could best support the Red Army's advance. The Russians made only one specific request, but made it insistently: that the Allies attack the oil fields at Ploesti rather than the marshalling yards there. They stated that changing battlefield conditions would dictate when the Allies could most profitably attack transportation targets in support of the Russian summer offensive, but that oil should be the focus for the time being. The timing of this visit was particularly significant, coming as it did during the opening of the oil campaign against German synthetic oil plants and just over a month into Spaatz's and Eaker's quasi-insubordinate campaign against the Ploesti oil refineries. The Russian emphasis on oil attacks not only confirmed their importance from

⁵⁶ HO 191/118, RE8, "Provisional Attack Assessment Report: Gelsenkirchen Benzin A.G. Gelsenkirchen Synthetic Oil Plant, Attacks of 12/13th, 14/15th and 15/16th June, 1944," 19 July 1944, 1-2; Middlebrook and Everitt, *Bomber Command War Diaries*, 527.

the USSTAF perspective, but probably also gave Spaatz the leverage he needed with Eisenhower to get him to approve concurrent transportation and oil offensives.⁵⁷

During a meeting on 13 May, General Vladimir Grendal, the Red Army's senior intelligence officer, emphasized that oil was the key target system for heavy bombers. He noted that the Germans on the Eastern Front had enough gasoline to use motor transport for their troops often, "And that the latest information available from PW's [prisoners of war] and other sources showed on the whole Soviet front from the Baltic to Roumania there was no shortage whatever of oil. That very large oil dumps have been built up and are kept well supplied."⁵⁸ Grendal's statement was both a criticism and a thinly-veiled request for USSTAF assistance in creating an oil crisis for German armies in the East. As we have seen, Spaatz and Bufton had already made the case for just such assistance, pointing out to Eisenhower that oil attacks would produce operational crises for German armies on *all* fighting fronts, including the crucial Eastern Front. As we will see, the oil offensive did this very effectively *in conjunction with* a brilliantly-executed series of Red Army offensives and several glaring German logistical deficiencies.⁵⁹

⁵⁷ Spaatz Box 316, "The Diary of USSTAF Mission to Russia in Connection with Frantic Project and Other Matters," May 1944, 4; MS16, S3, B4, F1, Cable, Major General Deane (Head of Military Mission to Moscow) to Spaatz, 10 May 1944. Deane said "the Russians considered the oil in Ploesti as being a primary objective."

⁵⁸ Spaatz Box 17, "Report on Visit to Russia by Mission of USSTAF Officers," Appendix B, "Conference with Gen Grendal," 21 May 1944, 2.

⁵⁹ Major General John R. Deane, Head of the American Military Mission to Moscow, 1943-45, noted the effects of the oil offensive during his tour of battlefield outside of Vilna just after the Russians retook the city in July 1944. "It was apparent," he said, "that the Russian victories were won by superior mobility. The combined bomber offensive of the Western Allies was taking its toll of German oil, and the German artillery and much of the transport we saw was mostly horse-drawn. The Russians with their preponderance of motorized equipment [and fuel] were thus able to outmaneuver the Germans." See John R. Deane, *The Strange Alliance: The Story of Our Efforts at Wartime Co-operation with Russia* (New York: The Viking Press, 1947), 207.

By late May, it was clear that attacks on Ploesti and German oil plants were already having an impact on German military operations and training. A JIC report noted that the German army had now joined the Luftwaffe and the *Kriegsmarine* on a fuel-quota system, with quotas being steadily reduced in the face of oil attacks. Fuel shortages were already hampering the training of German divisions in the West, which now received very little fuel for that purpose. The study concluded that if air attacks on oil plants and refineries continued, and a three-front Allied offensive began in the summer, "Within two to three months, depending on the circumstances, military supplies would have to be cut to an extent that would cause a most serious contraction in operational mobility...The position now is more vulnerable than at any previous time."⁶⁰ In anticipation of these effects, the Chiefs of Staff ordered the JIC to produce progress reports for the oil offensive every 2 weeks.⁶¹ By early July, the Germans had broken into their strategic reserves on all fronts and had begun to experience severe distribution problems, especially in the West, as we saw in the previous chapter, but also in the East. To deal with the crisis, OKW cut fuel quotas by 20 percent for all three services and on all three fighting fronts. A JIC report noted that continued oil attacks and combat on three fronts were depleting German supplies so rapidly that they would likely fall 35 percent short of the minimum needed to supply all combat divisions with adequate amounts of fuel.⁶²

To track these increasingly severe effects, the Allies established the Joint Anglo-American Oil Targets Committee and its JOTC to keep the German oil position under

⁶⁰ AIR 8/1018, JIC (44) 218 (O) (Final), "The Axis Oil Position in Europe, First Six Months of 1944" 27 May 1944, 1, 3, 7.

⁶¹ AIR 8/1018, "Extract from Minutes of C.O.S. (44) 201st Meeting (O), held 20th June, 1944," 20 June 1944.

⁶² AIR 8/1018, JIC (44) 285 (O) (Final), 4 July 1944, 3-4.

constant review, assess the effectiveness of attacks, and determine target priorities. This body served the same purpose as the Railway Targets Committee (RTC) during the transportation offensive in support of Overlord. It included the Allies' foremost oil experts, who had access to all BDA reports. Their weekly reports had a standardized structure that began with a review of attacks during previous week, the overall effects of the oil offensive on German production, current developments (including the status of synthetic oil plants and oil refineries), and the basis of future policy (which included recommendations for the coming week's attacks and any other issues of note). Once the committee had decided on target priorities, they sent a prioritized list to MAAF, USSTAF, and Bomber Command. Staff officers from the three commands then worked with each another to decide which targets each would attack during the coming week.⁶³

Coordination between the JOTC and the MAAF Oil Targets Committee (MOTC) became closer as the offensive developed. Lieutenant Colonel V. L. Forster, one of Great Britain's foremost oil experts, recommended that Flight Lieutenant Kent of the ACIU's D Section, "our expert oil interpreter," visit MAAF to teach photointerpreters there the finer points of producing damage assessments for oil targets. He also agreed with General Eaker's request to assign Mr. L. Eisinger, another key oil expert, to MAAF as the air staff's oil specialist. Forster said of Eisinger, who until his transfer had worked at the Middle East Supply Centre at Cairo, "No better candidate could be found and every confidence can be placed in his work and judgment." Forster's efforts also increased the effectiveness of BDA at the ACIU, where he brought Kent and his coworkers together

⁶³ See MS16, S5, B8, F7, "Joint Oil Targets Committee Weekly Bulletin No. 1," 5 July 1944, for a summary of the report's structure; see AIR 8/1018, Cable, Bottomley to Slessor, 8 July 1944, for the dispatch of JOTC target lists.

with leading petroleum engineers, who spent much of the next year providing detailed insights on damage assessments. These individuals had lent their time before, but the intensity of this work with the ACIU far surpassed anything they had done earlier.⁶⁴

As these various experts lent their services to the oil offensive, the JOTC had already begun releasing its weekly bulletins and target lists. The inaugural report noted that the Bergius plants at Zeitz and Gelsenkirchen Nordstern were both out of action until the end of the month, while those at Magdeburg and Böhlen were severely damaged and producing at reduced capacity or not at all. Leuna had been hit only lightly in the most recent round of attacks and was still producing at nearly full capacity. Brück was hit hard but still producing coal tar which could feed Bergius plants in eastern Germany. Pölitz, too, had been heavily hit, but reconnaissance cover revealed that it was receiving the highest priority for repair given its special equipment for producing aviation fuel. These intensive repair efforts, photointerpreters said, would have it producing at 50 percent of capacity within two weeks. Lützkendorf had also received significant damage but would likely be running at 50 percent of pre-attack capacity within the next week. The rest of Germany's oil plants and refineries, including the Bergius plants at Gelsenkirchen, Blechhammer South, and Blechhammer North, were fully operational. The report closed with a standard table appearing in all JOTC and CSTC Working Committee (Oil) reports. Entitled "Estimated Output of Axis Oil Plants," it assessed German oil production levels for the previous month, the current month, and the next month. The latter two were based on a "worst-case" scenario, standard among intelligence reports, which assumed Allied bombers did no additional damage to German oil plants and refineries. The figure

⁶⁴ AIR 8/1018, Memo, Lieutenant Colonel V.L. Forster to Portal, "Oil Targets," 24 July 1944, 1-2.

for June was 59 percent of pre-attack production, which made clear how rapidly and drastically the campaign was reducing the Reich's oil production.⁶⁵

By late July, a JIC report stated that an increasingly severe oil shortage was having a drastic impact on German operational capabilities. Synthetic oil production had plunged to 35 percent of pre-attack levels (from 495,000 tons to 171,000 tons), while oil reserves had plummeted from just over 1,000,000 to 573,000 tons. The monthly requirement for unrestricted military operations was 932,000 tons, which meant the Wehrmacht already faced a 38 percent deficit that could not be made good.⁶⁶

The intelligence source most important for making these assessments was Ultra. Although photointerpreters were able to determine with a high degree of accuracy the damage done by Allied raids, only Ultra could provide *definitive* confirmation of their assessments. Indeed, a postwar study claimed that Ultra reports concerning air attacks were most decisive with respect to oil attacks. "This evidence," it noted, "was so prompt and so persuasive that it may well be considered one of the principal contributions of Ultra to the conduct of the air war."⁶⁷ Scores of intercepts indicated a pervasive and severe fuel shortage on every fighting front. They gave airmen a firm assurance that the oil offensive was succeeding. One of the first was a 22 May intercept stating that strict economy in fuel consumption was imperative because, "in view of effects of Allied

⁶⁵ MS16, S5, B8, F7, "Joint Oil Targets Committee Weekly Bulletin No. 1," 5 July 1944, 1-4.

⁶⁶ AIR 8/1018, JIC (44) 320 (O) (Final), "Effect of Allied Air Attack on the Enemy Oil Situation in Europe," 24 July 1944, 3-4.

⁶⁷ RG457, E9002, B12, MIS SB Special Research History (SRH), SRH-017, "Allied Strategic Target Planning," August 1945, 2-3.

action in Rumania and on German hydrogenation plants, extensive failures in mineral production and a considerable reduction in the June allocation...are to be expected.”⁶⁸

Allied targeting of Bergius plants, which produced 90 percent of the Luftwaffe’s aviation fuel, impacted German air operations immediately. In June, *Reichsmarschall* Hermann Göring sent a message to all Luftwaffe commanders ordering “extreme measures on economy” for all non-combat flying, including pilot training.⁶⁹ In fact, the Germans had already broken into their strategic aviation fuel reserve to meet operational requirements.⁷⁰ On 30 June, Speer told Hitler:

The enemy has thus succeeded in increasing the decline in the production of aviation spirit to 90% on 22nd June. Only by the most rapid restoration of the damaged plants, which started up again long before the dates scheduled, has this catastrophic loss of the 22nd June been partially compensated...⁷¹

He then noted that if heavy attacks continued, aviation fuel stocks would be exhausted by September 1944—an accurate appraisal, as events were to prove.⁷² This memo and several others like it, which came to light during postwar interrogations, corroborated not only Ultra intercepts but also BDA reports produced as the oil offensive progressed.

By early July, Luftwaffe leaders had ordered that the taxiing of aircraft be cut to a minimum, the usual flying-away of aircraft during air raids discontinued, and the duration of test flights reduced. The first two orders presented obvious hazards to Luftwaffe

⁶⁸ Ibid., 24.

⁶⁹ AIR 40/2073, AI3(e), “M.S.S. References to Oil Shortages and Restrictions since May 1944,” 30 December 1944. This source provides the text of all Ultra intercepts from May to December 1944 relating to oil and fuel shortages. Göring’s directive was obtained in a 5 June 1944 intercept.

⁷⁰ Ibid., 9 June 1944 intercept.

⁷¹ AIR 20/8780, Control Commission for Germany (BZ), Field Information Agency, Report No. 62, Interrogation of Albert Speer on “The Effects of Aerial Warfare and Allied Successes on German War Production” (interviewed on 6 September 1945), 8 November 1945, 6.

⁷² Speer noted that production of aviation fuel ended quickly once the oil offensive got into high gear. Only trivial amounts were produced from June 1944 to the end of the war. See MS16, S5, B12, F11, ADI(K) Report No. 349/1945, “The Effects of the Allied Bombing of Germany,” 11 July 1945, 10.

aircraft on the ground, while the latter in effect robbed the German air arm of its seed corn, as did progressively severe restrictions on pilot training. This message was followed almost immediately by another from Göring stressing once again the need for “drastic economy” in the use aircraft fuel and ordered a major reduction of transport aviation flights.⁷³ In early August *Luftflotte 3* sent a message quoting a new Air Ministry order calling for even greater fuel economy in the face of continuing oil attacks. Only fighter air-defense activity remained unrestricted. All other flying, including pilot training, reconnaissance sorties, and bomber and ground-attack missions, was cut to the bone. Meteorological flights were discontinued altogether.⁷⁴

In a 29 July memo to Hitler acquired by Allied interrogators immediately after the war, Speer summed up these calamities. His tone was despondent:

In almost all cases (shortly after they had started work again) the enemy succeeded in destroying the plants with so lasting an effect that in July, instead of the expected increase, a decline in production had to be recorded, although the reconstruction measures had afforded prospects of a considerable increase...If... further attacks take place on the hydrogenation plants, and the enemy succeeds in throttling aviation fuel production to the same extent as he has done up to now, then the operations planned by the German Air Force will be completely impossible in September or October...All I can do is to point out that if the attacks continue, then on the basis of our experience in June and July, the German Air Force can reckon with a new production of not more than a maximum of 10,000 to 20,000 tons of aviation fuel in August and September.⁷⁵

By this time, intercepts also painted a grim picture of the effect oil attacks were having on German operations at the fighting fronts. On 16 August, *Generalfeldmarschall* von Kluge requested permission to withdraw from the Argentan-Falaise pocket, blaming

⁷³ AIR 40/2073, AI3(e), “M.S.S. References to Oil Shortages and Restrictions since May 1944,” 30 December 1944, 4 July and 6 July intercepts.

⁷⁴ Ibid., 11 August intercept.

⁷⁵ AIR 20/8780, Control Commission for Germany (BZ), Field Information Agency, Report No. 62, Interrogation of Albert Speer on “The Effects of Aerial Warfare and Allied Successes on German War Production” (6 September 1945 interview), 8 November 1945, 7. Emphasis in original.

a deficiency of fuel for his tanks and other vehicles. This followed an 11 August message from *Luftgau* West France declaring that “in all evacuations fuel stocks, down to the last pint, [must] be taken back” to the Reich in case of a general withdrawal from France. As we saw in the previous chapter, between the destruction of marshalling yards, fighter-bomber attacks on truck convoys, and SAS-Maquis ambushes, very little of the fuel made it that far.⁷⁶ In a 30 August memo to Hitler underscoring the significance of these Ultra intercepts, Speer warned that

The basis for army movements at the Front is getting so slight that planned operations can no longer take place in October. In the present fuel situation, it is no longer possible to gain offensive successes, as the fuel quantities required for the supplies necessary for an offensive are no longer available.⁷⁷

Intercepts of messages dealing with damage to oil plants and refineries were also valuable. A 16 July message from *Generalleutnant* Gesternberg, in charge of Ploesti’s air defenses, to military staffs and ministries in Berlin noted the effects of a 15 July attack on Ploesti, providing details on damage to specific components of the various refineries, the likely loss of production, and the approximate number of days required for repairs. A similar report of 22 July said “Hydrogenation works Maltheuren near Brueck [Brück]: damage to distillery, oxygen plant and among the tanks.”⁷⁸ These messages, and others like them, corroborated Allied BDA reports or, in cases where the two varied, provided “ground truth” about the exact extent of the damage.

⁷⁶ RG457, E9002, B12, MIS SB Special Research History (SRH), SRH-017, “Allied Strategic Target Planning,” August 1945, 24, 28.

⁷⁷ AIR 20/8780, Control Commission for Germany (BZ), Field Information Agency, Report No. 62, Interrogation of Albert Speer on “The Effects of Aerial Warfare and Allied Successes on German War Production” (interviewed on 6 September 1945), 8 November 1945, 10.

⁷⁸ RG457, E9002, B12, MIS SB Special Research History (SRH), SRH-017, “Allied Strategic Target Planning,” August 1945, 38.

Allied cryptographers also eavesdropped on Japanese diplomatic traffic between Berlin and Tokyo. The Japanese Naval Attaché noted that concerted attacks on Ploesti and synthetic oil plants were taking a serious toll on German fuel supplies. "Allied attacks against German oil resources," he said, "have caused considerable damage and the present production of fuel has fallen to about 50%..."⁷⁹ In August, he quoted the German liaison officer to the Japanese Embassy, who said, with surprising candor, "I fear that if raids of this kind are allowed to continue, Germany's capacity to prosecute the war will be very seriously affected." The attaché further noted that if attacks continued, German oil stocks would be depleted by mid-February.⁸⁰ A month later he said the Germans were beginning to run out of fuel.⁸¹

Postwar interrogations of German leaders further corroborated BDA reports and Ultra intercepts. One such interrogation confirmed that monthly receipts of aviation fuel fell from 150,000 tons in May 1944 to 52,000 tons in June and 7,000 tons in September. A slight recovery, to 18,700 tons in October and 39,200 tons in November, did not allow anything even remotely approaching full employment of available aircraft. Fuel was, ironically, in even shorter supply than pilots. Aviation fuel reserves also plummeted, with OKW stocks falling from 107,000 tons to 30,000 by November. The Führer's Reserve of 207,000 tons was entirely exhausted by then. As Ultra intercepts had noted, Nazi leaders confirmed that the full severity of the fuel shortage was felt starting in August 1944, as production and reserves plummeted. As a result, flying hours for pilot candidates were cut in half, and most bomber units were disbanded and their crews

⁷⁹ AIR 40/2073, AI3(e), "M.S.S. References to Oil Shortages and Restrictions since May 1944," 30 December 1944, 2, 24 July 1944 intercept.

⁸⁰ Ibid., 14 August 1944 intercept.

⁸¹ Ibid., 15 September 1944 intercept.

assigned to the infantry. "By February 1945, the report noted, "the GAF [German Air Force] fuel situation was desperate..." It remained so for the rest of the war.⁸²

As we saw in the previous chapter, this catastrophic fuel shortage developed not just as a result of heavy-bomber attacks on marshalling yards, synthetic oil plants, and refineries, but also because the Allies targeted *every* element of the Third Reich's fuel production and distribution infrastructure, from oil plants to depots and fuel convoys in the field. From 1 June to 31 July, Allied aircraft made 139 depot attacks in France, including a devastating attack on the huge fuel depot at Gennevilliers on 22 June. This raid was the first of many to inflict severe damage on German fuel depots in France and western Germany, speeding the exhaustion of fuel reserves, which were largely used up or destroyed by August and could not be replaced because oil attacks caused fuel output to plummet. The depot at Gennevilliers supplied 750 tons of gasoline a day to German troops in Normandy prior to the raid. These shipments ceased afterwards. Of the depot's 125 storage tanks, 60 were destroyed. A USSTAF ground survey team visiting the site in October learned that most of these tanks had contained gasoline. The Standard Oil plant adjoining the depot was also severely damaged. It had produced 2,200 tons a month of lubricants for German tanks.⁸³ Similar stories played out at scores of fuel dumps.

Attacks on depots increased in number during the summer. On 2 August, Allied bombers raided the huge depots at Bordeaux and Lyon, destroying 1,850,000 gallons of

⁸² Eaker B I:31, F1, "A.D.I.(K) Report No. 374/1945: G.A.F. Oil Supplies during the War," 13 August 1945, 1-2. This report included testimony from *Generalfeldmarschall* Erhard Milch, General Adolph Galland, and three other senior leaders engaged in various aspects of German combat aviation.

⁸³ AIR 37/850, SHAEF G-2, "Attacks on POL, Ammunition, and Supply Dumps—1 June to 31 July 44," 9 August 1944; SMS 347, S1, B2, F1, Major Mark H. Brown, USSTAF Ground Survey Team Leader, "Standard Oil Co. and WIFO Storage Depot, Gennevilliers (Paris), France, October 1944, 1-2.

fuel, or *two-thirds* of the remaining strategic reserve in France.⁸⁴ In late August, heavy bombers also severely damaged the underground-storage depot at Montbartier.⁸⁵ A ground survey and interrogations of key personnel, conducted on 16-17 December, gave the Allies a very detailed understanding of how German fuel depots were structured, including vulnerabilities associated with the pumphouse, loading facilities, pipelines, and electrical system. The team's report recommended 1,000-lb. semi-armor piercing bombs for future attacks, some set to several hours' delay, which would penetrate deeply enough to destroy buried storage tanks and damage other key components. It also recommended employment of incendiaries to start fires.⁸⁶

The ground survey reports from Gennevilliers and Montbartier serve as another reminder that Allied BDA experts were constantly involved in an iterative learning process that allowed them to maximize the effectiveness of future attacks by studying and applying lessons from previous ones. One of the most important from Montbartier was the discovery that 1,000-lb. bombs could in fact rupture underground storage tanks, something BDA experts had thought impossible prior to seeing firsthand the results of this raid. By October 1944, air intelligence personnel understood German depots well enough to recommend that fighter-bombers and medium bombers attack depots to destroy tank wagons, depot loading facilities, and sidings, while heavy bombers attack

⁸⁴ Spaatz Box 134, HQ 12th Army Group Interrogation Center, "Effects of US Strategic and Tactical Air Power," based on interrogations of Generalleutnant Zimmermann (G-3 for C-in-C West), *General der Kavallerie* Westphal (Chief of Staff), and Oberst John (G-4), 12 June 1945, 4.

⁸⁵ AIR 40/665, 6772-6773, BDA (K) Reports, Attacks on Montbartier Oil Dump; severe damage to oil tanks, 26 June and 30 June 1944.

⁸⁶ AIR 40/2117, CSTC Ground Survey Team, "Report on G.A.F. Buried Fuel Depot Montbartier," January 1945, 5.

underground storage tanks with 1,000-lb. bombs. This division of labor, worked out over several weeks of air operations, proved very effective.⁸⁷

These attacks on fuel depots also profited from an increasingly deep understanding of the German fuel-distribution system, which allowed them to locate and determine the importance of each depot, assign it a target priority, and lay on the required attacks, which were carried out by 8th Air Force heavies or 9th Air Force medium bombers. The process of locating fuel depots and piecing together the administrative structure within which they operated was complete by 1944. All depot operations were handled by an organization known as the *Wirtschaftliche Forschungs G.m.b.H.* (Economic Research Co.), known by its German acronym, WIFO. This organization controlled Luftwaffe and German army fuel supplies. There were 11 main depots (*Hauptlager*), nine of which were confirmed by reconnaissance cover. Fuel and additives such as benzol and alcohol were blended prior to shipment of fuel to the front. The WIFO infrastructure also included eight Transit Depots (*Umschlaglager*), which were rail loading points for fuel moving on the Elbe and Danube Rivers. Also important were Army Command Depots (*Nachshublager*). WIFO employees here filled drums for movement to army depots in the field. Nine of these were confirmed by PR cover. Field depots below this level were operated by army personnel.⁸⁸

With this detailed intelligence in hand, bomber crews attacked most of these depots and in several cases caused severe damage. Nienburg, a WIFO underground aviation fuel storage depot that was exceptionally well camouflaged, was attacked on 5 August by 176

⁸⁷ MS16, S5, B8, F4, JOTC, "P.O.L. Depot Bulletin No. 1," 3 October 1944.

⁸⁸ AIR 40/2073, USSTAF A-2, "German Oil Supply and Administration," 30 March 1945, 1-2.

8th Air Force heavy bombers, dropping 1,330 1,000-lb. bombs “with very satisfactory results.” These large weapons proved very effective against buried storage tanks, pipelines, electric cables, and loading points. Fires raged out of control for days, and special fire-fighting teams had to come from Bremen and Hamburg to put them out. The damage to rail and barge loading facilities was severe, and the latter were still un-repaired at time of capture. The depot was inactive for the next 6-8 weeks but was working at about 60 percent capacity when captured in 1945, indicating that more frequent attacks were necessary. In fact, this was a problem with depot attacks across the board.⁸⁹ What BDA experts learned too slowly was that the destruction of depot facilities, including pipelines, pumping units, blending and bulk-breaking equipment, and rail facilities, irrespective of the destruction of fuel, effectively shut down operations. In this case, the denial of fuel was just as important as its destruction. A CSTC ground survey team report concluded that “The amounts of fuel destroyed, or denied to the Germans through the destruction of depot facilities, far exceeded our expectations.”⁹⁰ Also, because synthetic oil plants and crude oil refineries had been sending fuel, fuel components, and lubricating oils directly to the depots to minimize the chances that such products would be destroyed by air raids, the depots in fact completed the final steps in the production process, including bulk-breaking and blending.⁹¹ Air intelligence officers missed these crucial facts. They did recognize that some blending was done at the depots as a matter of course but failed to see how quickly the Germans were sending fuel and blending

⁸⁹ AIR 40/1515, CSTC Working Committee (Oil), “Report on a Tour of German P.O.L. Depots,” 1 June 1945, 3-5; AIR 2/8011, Minutes, CSTC 11th Meeting held on 27 December 1944, 30 December 1944.

⁹⁰ Ibid., 1.

⁹¹ Ibid., 1-2.

agents to the depots. Had heavy attacks on depots begun earlier and been more frequent, they would have had an even greater impact on German tactical and operational mobility.

As intelligence officers struggled with questions surrounding the efficacy of attacking fuel depots, Bufton sent a memo to Portal emphasizing that there was as yet no formal directive for Bomber Command attacks on synthetic oil plants in the Ruhr. He noted that destroying these plants was vital to the success of the oil campaign. Bomber Command area raids had done some damage, but only precision attacks would put them out of action. Bufton noted in a postscript:

Not only because of the intrinsic importance of these plants, but also in the interests of the prestige of the R.A.F. vis-à-vis the Americans, I consider it of extreme importance that Bomber Command should achieve success against the Ruhr plants without delay. The urgency of the task is such that the Americans must destroy them if Bomber Command do not.⁹²

Portal then put pressure on Harris to make a major contribution to the oil campaign, which he did reluctantly. The Bomber Command effort got underway the night of 18-19 July with attacks on Wesseling and Scholven, both of which were put out of action for several weeks. Around 1,000 bombs landed in the Wesseling plant area, and another 550 on Scholven. The larger number of Oboe and Gee stations, several of which were on the Continent, played a key role in this very accurate bombing. These two attacks heralded the end of German oil production in the Ruhr. Indeed, subsequent attacks were made in daylight with fighter escort, and in conjunction with 8th Air Force raids, they knocked out every one of the 10 major synthetic oil plants and crude oil refineries in the Ruhr by the

⁹² AIR 8/1018, Memo, Bufton to Portal, "Bomber Command's Attacks on Synthetic Oil Plants in the Ruhr," 7 July 1944, 4.

end of September. From there, periodic "policing" raids were made as one plant or another showed signs that it was ready to resume production.⁹³

As these attacks developed, the JOTC's second weekly report noted that the Bergius plants at Zeitz, Gelsenkirchen-Nordstern, Böhlen, and Pölitz were out of action until August. A report from a human intelligence source, corroborated by reconnaissance cover, confirmed that serious damage to Ploesti's marshalling yards had reduced considerably the movement of fuel from there to Germany and the Eastern Front. Damage to pumping stations also prevented the shipment of oil up the Danube. Consequently, because surplus fuel and oil production could not be shipped, the Roumanians had to shut down two-thirds of their oilfield production while awaiting repairs to these bottleneck facilities. The report closed with guidance for MAAF to keep pumping stations and loading terminals out of action, continue mining the Danube, and carry out attacks on the tugboat fleet. To hamper rail shipments, MAAF bombers were to continue attacking marshalling yards and interdicting bridges between Ploesti and the Eastern Front. These targeting priorities again underscored Allied efforts to assist the Russian advance by starving the Germans of fuel.⁹⁴

By the end of July, production of finished POL products had dropped from 1,360,000 tons per month in March 1944 (the pre-attack total) to 673,500 tons in July (49.5 percent of pre-attack total). To make matters worse for the Germans, fuel shipments from Ploesti had nearly ceased due to the mining of the Danube and attacks on Ploesti's marshalling

⁹³ Middlebrook and Everitt, *The Bomber Command War Diaries*, 545; AIR 14/1210, Bomber Command, "Review of Work of Intelligence 1 Section (Target Intelligence & Damage Assessment) 1939-1945," 18 August 1945, 20-21, 45-48.

⁹⁴ MS16, S5, B8, F7, "Joint Oil Target Committee, Working Committee, Weekly Bulletin No. 2," JOTC, 11 July 1944, 4-8; MS16, S3, B4, F1, Cable, HQ MAAF to USSTAF and AFHQ, "Priorities for bombing Effort in South-East Europe," 25 July 1944.

yards and bridges between there and the Eastern Front. Continuing raids on Ploesti had nearly brought fuel production to a standstill. Less heartening, however, was the faster-than-expected repair of oil plants⁹⁵

By the middle of August, these efforts had put Leuna, Zeitz, and Böhlen back in production. In addition, production was about to resume at Magdeburg, Scholven, Gelsenkirchen-Nordstern, Pölitz, and Wesseling, and all the Fischer-Tropsch plants, with the exception of Homberg, were back in full or partial production. The bulletin concluded with a clear warning to Allied senior airmen: "A strong resurgence of activity in oil production in Germany is therefore imminent."⁹⁶ Consequently, the JOTC sent out a new target list with 89 oil targets, including 16 depots, calling for attacks on all plants about to come back on line and a continuation of raids on Ploesti.⁹⁷

Allied senior airmen took this warning to heart and ordered another round of heavy attacks. They were also spurred on by a JIC report emphasizing the general and increasingly severe curtailment in Luftwaffe operations and stating that "the operational efficiency of the German Army, notably in the West, is being drastically affected by lack of fuel which has been a major factor in the present battle."⁹⁸ They also noted a statement by the British Chiefs of Staff that

Further reduction in the enemy's oil supplies may be expected to precipitate large scale catastrophes on both the Western and Eastern Fronts, by drastically impairing the mobility of his Army and Air Force formations. Specific recommendations:

⁹⁵ MS16, S5, B8, F7, JOTC, "Joint Oil Target Committee, Working Committee, Weekly Bulletin No. 4," 25 July 1944, 1-5; MS16, S5, B8, F7, JOTC, "Joint Oil Target Committee, Working Committee, Weekly Bulletin No. 5," 1 August 1944, 1-2.

⁹⁶ MS16, S5, B8, F7, JOTC, "Joint Oil Target Committee, Working Committee, Weekly Bulletin No. 7," JOTC, 15 August 1944, 1-2. Emphasis in original.

⁹⁷ MS16, S3, B4, F1, JOTC, Target List, 16 August 1944.

⁹⁸ AIR 8/1018, JIC (44) 365 (O) Final, "Effect of Allied Oil Attack on the Enemy Oil Situation in Europe," 21 August 1944, 2.

Attack of remaining Bomber Command oil targets in the Ruhr should always have priority over city targets. Conduct large-scale heavy bomber raids against all major tactical and strategic German oil depots. It is therefore recommended that when this Paper is forwarded by the Chiefs of Staff to the Supreme Commander, the latter's attention should be drawn to the importance of intensifying our attacks upon oil targets...⁹⁹

The next JOTC bulletin warned that the summer weather was about to come to an end, making an all-out effort against oil targets absolutely imperative. The proposed goal was to put the 25 largest oil plants and refineries out of action for at least two months. This would mean attacking large plants that were currently inactive to ensure these damage levels rather than going after smaller, but active, producers. "Successful attack of these 25 targets before the end of August or early in September," the bulletin concluded, "would result in the reduction of Axis oil production in September to less than 500,000 tons or about 35% of the original monthly production."¹⁰⁰

Heavy attacks on oil during the following week, and the defection of Rumania to the Allies, proved disastrous for German armies and air forces in the field. With the loss of Ploesti, total production of finished products, including gasoline and aviation fuel, would be no higher than 539,000 tons, only 40 percent of the pre-attack total. There were no Bergius plants operating, only three Fischer Tropsch plants active, and one refinery in Germany but four in Austria and three in Hungary. The weekly bulletin closed with a strong statement about future possibilities:

The Allied Air Forces are now presented with an unparalleled opportunity. It is within their power, by further attacks within the next few weeks, to create conditions of stringency which might well have decisive effects on the enemy's ability to

⁹⁹ AIR 8/1018, "Effect of Allied Air Attack on Enemy Oil Situation in Europe" (JIC (44) 365 (O)), 21 August 1944, and associated paper produced as the result of a COS Meeting on 22 August 1944 to discuss the oil offensive.

¹⁰⁰ MS16, S5, B8, F7, JOTC, "Joint Oil Target Committee, Working Committee, Weekly Bulletin No. 8," 22 August 1944, 7-8.

continue the war...If this aim is to be achieved it is essential that the re-attack of potentially important producers should not await confirmation that the plants have resumed activity. In the present situation no opportunity should be lost of prolonging their inactivity by renewing the attack.¹⁰¹

Although the Allies were not quite as close to finishing off the Reich as this statement suggested, the German fuel situation became disastrous with this turn of events.

In fact, an RE8 report indicated that while German repair efforts were impressive, they did not change any of the basic assumptions involved in assessing repair times after bombing raids. The report indicated that depending on the severity of damage, oil plants invariably shut down for 1-4 weeks after an attack in which it sustained damage, and that damage to or destruction of key components would halt production pending repairs or replacement of that key element (a serious problem given the shortage of spares). It further noted that damage to vital components would limit the level of production but *not* preclude it (which accounted for the fact that oil plants were often able to produce small quantities of oil and fuel prior to being attacked again), and that the order of repairs was designed to restore partial production as quickly as possible.¹⁰²

By September, a JOTC weekly bulletin noted that there was now widespread evidence that the Germans were using gasoline blended with benzol. Of the 20 major benzol plants, which produced a total of 35,000 tons per month, 16 were in the Ruhr and thus vulnerable to precision attacks by Bomber Command. Benzol was vital because it raised the octane level of gasoline and thus allowed further blending with alcohol. This

¹⁰¹ MS16, S5, B8, F7, JOTC, "Joint Oil Target Committee, Working Committee, Weekly Bulletin No. 9," 29 August 1944, 5-8. Emphasis in original.

¹⁰² HO 191/118, RE8, "Analysis of Repairs at Damaged Synthetic Oil Plants," September 1944, 1-5.

three-substance blending became the norm at German depots for the rest of the war.

Benzol plants thus came under immediate attack.¹⁰³

10.4 New Allied Bombing Directives: Staying the Course

As oil attacks reached a new level of intensity in September, Allied Expeditionary Air Forces (AEAF), which had been created to place all air assets under Eisenhower's control, ceased to exist on 15 September. Control of heavy bombers reverted to Portal and Arnold, who gave executive authority for pressing home the oil and transportation offensives to Air Marshal Norman Bottomley, the RAF's Deputy Chief of Air Staff, and to Spaatz. The earlier CBO mission statement was changed to read: "The overall mission of the Strategic Air Forces is the progressive destruction and dislocation of the German military, industrial and economic systems and the direct support of land and naval forces." Gone, at last, was any reference to morale. The Combined Chiefs of Staff, who presided over these changes, also emphasized that heavy bombers were to support the Red Army's advance whenever possible.¹⁰⁴ The follow-on directive, from Bottomley and Spaatz, gave the German oil industry (with an emphasis on gasoline and aviation fuel output) and transportation networks (railroads and canals) highest priority. "Our major efforts," it said, "must now be focused on the vital forces of Germany's war economy."¹⁰⁵

Buften and Spaatz also made sure their message stayed loud and clear: Keep after oil. In an attachment to a JIC report published in October, Buften said

It is considered that the Strategic Bomber Forces could make no greater contribution to the Allied land offensives, not only on the Western Front but equally on the

¹⁰³ MS16, S5, B8, F7, JOTC, "Joint Oil Target Committee, Working Committee, Weekly Bulletin No. 11," 14 September 1944, 1-3. Micro-H was an improved version of Gee-H.

¹⁰⁴ Spaatz Box 186, Cable, CCS Directive, 15 September 1944, 1-2.

¹⁰⁵ AIR 8/1745, Bottomley and Spaatz, Directive #1, "Directive for the Control of Strategic Bomber Forces in Europe," 25 September 1944, 1-2.

Russian and Italian Fronts than by preventing the enemy's oil production rising above its present level or, if possible by reducing it.¹⁰⁶

He then emphasized that the Ruhr had 43 percent of Germany's synthetic oil production and about two-thirds of its Benzol production. It was also close to the front lines, meaning these fuels could reach the front quickly and with a minimum of transportation requirements. The implicit argument was that Bomber Command attacks against these key targets must continue. Spaatz did his part by telling Lieutenant General Doolittle and Major General Twining, the 8th and 15th Air Force commanders, to keep attacking oil, even in the approaching bad weather. Without concerted attacks, repair efforts would raise oil production from 25 percent of pre-attack level in September to 42 percent by the end of October. The Allies, Spaatz said, could not allow an increase in oil production and the consequent rebound in enemy operational capabilities.¹⁰⁷

Spaatz's warning was especially urgent given the continuing stream of Ultra intercepts and POW interrogations highlighting the operational cataclysm befalling German armies and air forces on every front, and the equally clear indications of all-out German repair efforts. A JOTC bulletin published at the beginning of October noted

Abundant and increasing evidence that this low level of [fuel] production is causing a crippling restriction of enemy's operational activities. Desperate picture of the situation is reflected in the exceptional repair measures adopted by the enemy. It is estimated that in the absence of further attack these measures will almost double output in October raising it to 42% of pre attack."¹⁰⁸

In fact, by this time the Allies knew that Speer had placed one of his most capable subordinates, Edmund Geilenberg, in charge of the repair effort and given him 300,000

¹⁰⁶ AIR 8/1018, "Effects of Allied Attacks of Enemy Oil Situation in Europe, Report by the Joint Intelligence Sub-Committee," JIC(44) 423(O) (Final), 2 October 1944, 1-2.

¹⁰⁷ Spaatz Box 19, Memo, Spaatz to Doolittle and Twining, 3 October 1944.

¹⁰⁸ MS16, S3, B4, F2, Cable, JOTC to Bomber Command, USSTAF, and SHAEF, 2 October 1944.

skilled, servile, and slave laborers to effect repairs as rapidly as possible. The importance Speer and Hitler attached to Geilenberg's mission became clear in the Führer's proclamation of 30 May 1944 making Geilenberg "Plenipotentiary General for Immediate Action" to repair oil plants and giving him authority to take all necessary measures, including curtailing other war industries.¹⁰⁹ After the war, Speer revealed that Geilenberg's efforts usually allowed the resumption of small-scale production at oil plants, amounting to 10-14 days' normal production, before the next round of Allied raids. This was a rare instance in which BDA experts missed a key development.¹¹⁰

In addition to repairing existing plants, these workers were also building a number of small oil plants and refineries, which made the heavy-bomber crews' work even more urgent.¹¹¹ So urgent, in fact, that a JOTC targets list echoed the Bottomley-Spaatz bombing directive in emphasizing the importance of going after major oil plants:

all major oil objectives which are suitable for attack by blind bombing technique should be so attacked forthwith even though relatively more tonnage will be required than by visual methods...Whenever visual bombing opportunities occur it is essential that a much heavier scale of destruction should be inflicted than has hitherto been achieved in order to secure long term immobilization of plants attacked and...to reduce the necessity for making repeat attacks so frequently...¹¹²

¹⁰⁹ AIR 20/8780, Control Commission for Germany (BZ), Field Information Agency, Report No. 62, Interrogation of Albert Speer on "The Effects of Aerial Warfare and Allied Successes on German War Production" (interviewed on 6 September 1945), 8 November 1945, 5.

¹¹⁰ AIR 20/8779, SHAEF G-2, "Interrogation of Albert Speer, former Reich Minister of Armaments and War Production, 6th Session, 1500-1700 hrs., 30th May 1945," 30 May 1945, 3.

¹¹¹ AIR 8/1018, 6348-6353, JIC (44) 450 (O) Final, "Effects of Allied Attacks on the Enemy Oil Situation in Europe," 30 October 1944, 3-5; MS16, S5, B12, F14, *The United States Strategic Bombing Survey Summary Report (European War)*, 30 September 1945, 8.; AIR 20/8779, SHAEF G-2, "Interrogation of Albert Speer, former Reich Minister of Armaments and War Production, 6th Session, 1500-1700 hrs., 30th May 1945," 30 May 1945, 3. After the war, Albert Speer made an intriguing statement about this issue of underground oil production: "In 1916 when the Leuna works were built in middle Germany Ludendorff insisted that the works be put underground which shows the real greatness of that man. Our chemical industry learned nothing but built their whole industry very carelessly in regard to their attacks." While the "greatness of that man" is debatable, he certainly had the right idea in this case. These comments are in RG243, E31, B1, 8519-8520, "USSBS Interview No. 11, Subject: Reichsminister Albert Speer, 31 May 1945, Minutes of 19 May interrogation, 13.

¹¹² MS16, S3, B4, F3, JOTC Target List, 5 October 1944, 3-4.

Although Bottomley and Spaatz were concerned about the potential resurgence of oil production, they had the advantage of knowing, with great accuracy, where the Reich's oil position stood from week to week, and expert advisory bodies to help them make the right targeting decisions.

10.5 The Targeting-Bombing-BDA Feedback Loop: Oil and the CSTC

In fact, Bottomley and Spaatz were also determining how best to bring together targeting and BDA functions for *all* high-value target sets under a single advisory body. They decided to combine the functions of the RTC, the JOTC, and the Jockey Committee (formed in 1943 to make targeting recommendations for the attack on the Luftwaffe). This committee, they said, must have the expertise to monitor the latest BDA reports, build the most effective target lists, and submit those lists each week for Bottomley and Spaatz to review and approve. In a memo to Spaatz, Bottomley set forth his vision for this group of targeting and BDA experts:

I feel that one of the first things we must put on a sound footing is the advice we get as to target priorities in the various systems of strategic objectives. For this purpose, I suggest that we constitute at once a Strategic Objectives Target Committee, whose function will be to advise us jointly on this matter, and to be responsible for the compilation of the target list dealing with strategic objectives which are periodically updated...The Main Committee could regulate the activities of the various joint sub committees and working committees dealing with Oil, Transportation, and the G.A.F. In this way, the whole system of examination of strategical target systems and strategical target priorities could be properly managed.¹¹³

Spaatz agreed wholeheartedly, and within three weeks of Bottomley's memo the Combined Strategic Targets Committee (CSTC) was up and running.¹¹⁴

¹¹³ AIR 20/3228, Memo, Bottomley to Spaatz, 28 September 1944, 2.

¹¹⁴ AIR 20/3228, Memo, Anderson (Spaatz's deputy) to Bottomley, 5 October 1944.

They made the CSTC be as small as possible to allow for rapid decision-making, but also flexible enough to allow for visiting experts to shed light on the targeting process. The CSTC had permanent representatives from the Air Ministry's Directorate of Bombing Operations (including Bufton, the British Co-Chair), Bomber Intelligence Directorate, and Operations Directorate; the USSTAF Operations Directorate (including Maxwell, the American Co-Chair), Intelligence Directorate, and Enemy Branch; MEW; EOU; and SHAEF. Bufton and Maxwell chaired alternating meetings. A month after the CSTC's founding, representatives from Bomber Command and 8th Air Force joined the group. Also, experts from the Office of the Petroleum Attaché at the American Embassy, the Americans' Enemy Oil Committee, and the British Ministry of Fuel and Power provided insights, while Flight Lieutenant Kent of ACIU D Section and representatives from the JPRC often attended to provide the latest BDA.¹¹⁵ The CSTC advised Bottomley and Spaatz by recommending target priorities and putting forward SHAEF proposals for the employment of the heavy-bomber force in direct support of Allied ground forces. Also, the CSTC issued weekly prioritized target lists, which were drafted and discussed in the working committees on oil, transportation, and the Luftwaffe.¹¹⁶

Bufton and Maxwell proved to be tireless advocates for the oil offensive, and their energy paid huge dividends, particularly as summer turned to fall and the opportunities for visual bombing decreased. The CSTC's first weekly bulletin, which picked up where

¹¹⁵ AIR 20/3228, Memo, ACAS(O) (Air Vice Marshal T. M. Williams) to Tedder, Spaatz, Harris, MEW, and EOU, 13 October 1944, 1-4; AIR 20/3228, Memo, Williams to Harris, 7 November 1944; AIR 2/8011, CSTC, "Combined Strategic Targets Committee, Minutes of the 28th Meeting held in the Air Ministry, Whitehall, on Wednesday, 2nd May, 1945," Appendix D: "C.S.T.C. Working Committee (Oil)," 11 May 1945, 1-2. (Note: Future references to minutes of CSTC meetings will be abbreviated as follows, using this meeting as an example: Minutes, CSTC 28th Meeting held 2 May 1945, 11 May 1945, 1-2.)

¹¹⁶ AIR 20/3228, Memo, Williams to Tedder, Spaatz, Harris, MEW, and EOU, 13 October 1944, 1-4.

JOTC bulletins had ended, contained several sobering facts. The first was that the only oil attacks during the previous week had been by MAAF bombers; bad weather had kept 8th Air Force and Bomber Command grounded. Second, the quantity and quality of post-raid reconnaissance photos was poor owing to the bad weather, meaning there were eight synthetic oil plants whose operational status was in doubt owing to the absence of BDA for past attacks, dating back in one case all the way to 12 September. Third, these problems pointed to a major resurgence in German oil production, from 319,600 (23.5 percent of pre-attack capacity) in September to an estimated 503,000 tons (37.5 percent of pre-attack) in October and 641,000 tons (47.5 percent of pre-attack) in November. Fourth, there were clear indications that benzol plants were now supplying a major portion of the German army's fuel needs, and there were over 50 of these small plants to be attacked if this problem was to be brought in hand.¹¹⁷ Put simply, Bufton and Maxwell were placed immediately in the unenviable position of seeing that Allied bombing kept oil production at the September level but with fall and winter weather upon them. Still, they had Bottomley's and Spaatz's full support. In a memo to Eaker noting that an updated bombing directive was on the way as the result of a recent conference among senior airmen, Spaatz said

The results of this conference indicated that not only should oil continue on first priority, but that attacks against the German petroleum production, distribution, and supply points should be intensified by every means available by all Air Forces...New ways must be found to destroy oil wherever it can be found. Our studies have shown that for every ton of bombs dropped by the Strategic Air Forces the Germans are denied 61 tons of oil.¹¹⁸

¹¹⁷ MS16, S5, B8, F7, CSTC, "Combined Strategic Targets Committee, Working Committee (Oil Production), Weekly Bulletin No. 16," 17 October 1944, 1-2.

¹¹⁸ MS16, S3, B4, F3, Cable, Spaatz to Eaker, 1 November 1944.

Nonetheless, Bufton, Maxwell, and their CSTC colleagues had to contend with the weather and the addition of several benzol plants to the target list. In fact, at the first CSTC meeting Mr. Lawrence of MEW introduced the Working Committee (Oil) report, noting the Ruhr's synthetic oil and Benzol plants accounted for 43 percent of Germany's synthetic oil production and 67 percent of its benzol. Further, the benzol plants required immediate attack as reconnaissance cover just obtained on a rare sunny day showed many tank cars in the sidings at these plants. Major Beeson of SHAEF also emphasized the importance of continuing attacks on depots. All agreed that they should have the same priority as all other oil targets.¹¹⁹

Bufton also emphasized that the CSTC needed to show senior air commanders, as well as Eisenhower, two things: the effect upon the enemy of continued oil attacks, and effects on the Allied ground advance of any major diversion of heavy-bomber effort to transportation targets. These assertions related to Ike's request for a plan to attack the Rhine-Ruhr transportation network in an effort to break through to the Rhine, cross it, and force a German surrender by the end of 1944. Bufton pointed out that a recent assessment said the Germans needed 40 trainloads of supplies a day to allow for unimpeded defensive operations along a static front. He further noted that bad weather and increased oil production would more than cancel out any benefits of an all-out effort against transportation targets. The CSTC concluded that if the Allies had any hope of meeting Ike's objective to break the enemy in 90 days, continued attacks on oil targets offered the only good chance of success. Nonetheless, to mollify Ike, the CSTC settled on a plan for the attack of 16 bridges, with 2,500-3,000 heavy-bomber sorties, but

¹¹⁹ AIR 2/8011, Minutes, CSTC 1st Meeting held 18 October 1944, 23 October 1944, 2-8.

attached a strongly-worded caveat that such a plan would not be enough to isolate the German army from its sources of supply. German pioneer units had already thrown 14 pontoon bridges across the Rhine to compensate for Allied bridge attacks, and they could build more. The CSTC estimated that it would take 14,000 heavy-bomber sorties, in visual bombing conditions, to make the Ruhr-Rhine transportation plan work.¹²⁰ Once Bottomley and Spaatz added their weight to these arguments, Ike relented, although the smaller version of the Ruhr-Rhine transportation campaign proceeded. The key issue here is not that the CSTC was opposed to in principle to transportation attacks, but rather that they saw *this* particular plan had no real chance of success. Bufton and Maxwell also forestalled a second effort in November to divert heavy bombers from oil targets, noting:

From the strategic aspect the greatest contribution which the strategic bomber forces can make to the defeat of the German Armies in the West is by maintaining pressure on the enemy's sources of oil supply. It should be noted that the contribution which can be made in this respect extends automatically to the Armies on the Russian and Italian fronts.¹²¹

In fact, Spaatz told Arnold that Ike strongly supported a continued emphasis on oil followed by transportation attacks on marshalling yards and bridges in the Ruhr-Rhine region. Spaatz also said he and Bottomley were issuing a new bombing directive reconfirming these priorities. It emphasized the coordination of tactical and strategic air forces in oil and transportation attacks, and thus in their contribution to the advance of Allied armies.¹²² Spaatz closed by saying:

¹²⁰ AIR 8/1745, CSTC, "Meeting to Consider the Possibility of Isolating by Air Action against the German Armed Forces on the Western Front from Their Supply Bases, and in particular from the Ruhr and Frankfurt Areas," 24 October 1944, 1-5.

¹²¹ AIR 2/8011, CSTC, "Appreciation of the most effective utilization of the Strategic Air Forces on the assumption that the German Army West of the Rhine will be defeated on or before 1st January, 1945," 23 November 1944, 1.

¹²² AIR 8/1745, Spaatz and Bottomley, Directive #2, strategic bombing objectives, 1 November 1944.

All evidence we have obtained indicates that our attacks during the past two months have been most effective in achieving their end, i.e. (1) reducing mobility of the German Army; (2) major curtailment in Luftwaffe operations; (3) denying much needed tanks and other vehicles to equip the new German divisions being formed; (4) achieving considerable disruption of the lines of communications in Western Germany. General Eisenhower strongly supports this modified policy.¹²³

Spaatz made this statement because by then it was clear that a catastrophic fuel shortage had already led to several German operational disasters and would lead to several more.

10.6 The Disaster Builds: Oil Attacks and German Operational Difficulties

Aside from the central role of fuel shortages in the German collapse in Normandy and then throughout France, which we addressed earlier, a number of Ultra intercepts made it equally clear that fuel shortages were now having a major impact on German army and Luftwaffe operations on all the fighting fronts, including the crucial Eastern Front. In early September, a message from *Jagdkorps* II in France stated that all single-engine fighters were grounded for lack of fuel, a condition that persisted as the Germans tried to find enough fuel to fly these aircraft out of France during the retreat.¹²⁴ On the South Russian Front, Luftflotte 4 reported serious fuel shortages and ordered *Fliegerkorps* I to operate with the minimum required forces—not a good development given the desperate need of retreating German army units for air support.¹²⁵ On 13 October, *Luftgau* VII in Germany stated that the strictest fuel economy measures were necessary because no more fuel would be available *until the end of November*.¹²⁶ A few days later, the Technical Branch of the Air Ministry at Goslar said all aircraft were out of

¹²³ AIR 8/1745, Memo, Spaatz to Arnold, 28 October 1944, 2.

¹²⁴ AIR 40/2073, AI3(e), "M.S.S. References to Oil Shortages and Restrictions since May 1944," 30 December 1944, 1 September intercept.

¹²⁵ Ibid., 6 September intercept.

¹²⁶ Ibid., 13 October intercept.

fuel and no further flight testing was possible. The Luftwaffe's Research, Development, Testing, and Evaluation (RDT&E) program had come to a screeching halt.¹²⁷

Even more worrisome was an order from the Commander-in-Chief West (von Rundstedt) requiring the most stringent measures to cut down on motor transport traffic, urging the use of horse-drawn wagons and producer-gas vehicles to supply Panzer and Panzer Grenadier divisions. Even these key units, whose mobility was vital to their combat effectiveness, were demotorized as a result of the oil offensive and remained so, with the very partial exception of the Ardennes Offensive, for the rest of the war. In fact, only 300 tons of motor fuel was issued during the next 10-day period, one-sixth of the normal allowance. This meant that each division in the Western Front's two Army Groups received about five tons (1,200 gallons) per day as opposed to the standard of 30 tons (7,200 gallons) per day.¹²⁸ These reduced allotments proved adequate to maintain a largely static front with only defensive operations. They would not be even marginally sufficient once the Allies breached the Rhine River the following spring.

At the end of October, Göring issued another order for further drastic curtailment of all flying operations. Fighter operations were allowed only when contact with the enemy was likely. The same day, cryptographers intercepted a message stating that *Luftgaue* in western Germany were now using draft oxen to tow aircraft and heavy equipment.¹²⁹ By November, numerous aircraft units were sending messages saying they were out of fuel. In fact, there were 12 separate intercepts dealing with this problem.¹³⁰ At the same time, Luftflotte 4 on the South Russian Front ordered that, owing to severe fuel shortages,

¹²⁷ Ibid., 18 October intercept.

¹²⁸ Ibid., 25 October intercept.

¹²⁹ Ibid., 31 October intercepts.

¹³⁰ Ibid., 1-10 November intercepts.

operations by front-line units would be severely restricted and undertaken only when success was certain or the occasion critical.¹³¹

As Ultra recorded these German operational calamities, Harris was once again doing what he could to keep his heavy bombers pointed at German cities rather than at oil targets. At the beginning of November, he sent a memo to Portal reminding him, quite properly, that Bomber Command was playing the leading role in attacks on synthetic oil and benzol plants in the Ruhr. From there, however, he said the oil offensive was overblown. Too many cooks, he said, were now "engaged in stirring the broth...every panacea monger and 'me too expert'...has raised his head again."¹³² Then, inevitably, he reminded Portal that "In the past 18 months Bomber Command has virtually destroyed 45 out of the leading 60 German cities..."¹³³ Harris was still hooked on city bombing, and this was about to get him in very hot water with Portal.

During the first five months of the oil offensive, it had become clear that USAAF raids were incapable of doing the same level of damage to oil plants as were Bomber Command raids. In addition to carrying much heavier bomb loads, RAF bombers could rely on very accurate target marking by a veteran Pathfinder Force. With winter on the way and the large Bergius plants coming back on line, Bufton and Maxwell recognized that only Bomber Command could inflict the level of damage required to keep those plants out of action for long periods. In addition, the short winter days made it impossible for USAAF bombers to carry out daylight attacks on distant oil plants in eastern Germany and southwestern Poland. The problem was convincing Harris to

¹³¹ Ibid., 10 November intercept.

¹³² AIR 8/1745, Memo, Harris to Portal, 1 November 1944, 2.

¹³³ Ibid., 3.

expand on his command's "policing" attacks against oil targets in the Ruhr by adding night precision attacks against distant Bergius plants. On 3 November, Bufton and Maxwell said "that RAF Bomber Command should give special consideration" to the attack of distant Bergius plants, including Leuna and Pölitz, in central and eastern Germany.¹³⁴ They continued:

If enemy plants had been successfully re-attacked whenever opportunity occurred, even though still inactive, the enemy would not have been able to achieve the increase of oil production from 23.5% of his pre attack output in September to 32% in October. Over the winter months a further recovery in German oil production can only be averted by seizing the few expected opportunities of effecting long term damage to the major productive plants even though these plants may not have resumed production by time of attack. The aim should now be to complete the destruction of all major producers.¹³⁵

The establishment of the CSTC and its Bufton-Maxwell co-chairmanship proved highly significant in several ways, not the least of which was this pressure on Bomber Command to carry its weight in the oil offensive. Bufton had the added advantage of having Portal's full confidence. He and Maxwell were thus able to convince Portal that Bomber Command attacks on distant Bergius plants were crucial. Harris, however, was not eager to play along. In fact, he instead ordered area raids on Cologne and Bochum, on nights well suited for oil attacks, *after* receiving guidance from Portal to go after distant Bergius plants. The result was perhaps the most severe dressing-down Harris received during the war. That Portal, a very effective but self-effacing leader who sought to avoid acrimony, dropped the hammer on Harris indicates just how important he thought the oil offensive was in hastening the Allied victory.

¹³⁴ MS16, S3, B4, F3, CSTC Target List, 3 November 1944, 2.

¹³⁵ Ibid., 4.

Portal, responding to a memo in which Harris had given him eight reasons why bombing Cologne and Bochum was preferable to going after oil targets, noted acerbically: "All I needed was one good reason, and I confess that when I get eight reasons I begin to wonder whether all of them are equally good!" He then made the following observation:

I would...say, at the risk of your dubbing me 'another panacea merchant', that I believe the air offensive against oil gives us by far the best hope of complete victory in the next few months. It will be a terrific battle between destruction and repair and we cannot afford to give a single point away...I was very much worried by the German recovery in oil production, and I hope that you will give the very greatest weight [to oil as the highest-priority target set]...¹³⁶

Having by now presumably gotten Harris's undivided attention, Portal closed with a warning:

In view of the vital importance of getting the German war finished as soon as possible and of the disastrous delay that would result from any substantial recovery of the German oil position, I make no apology for inflicting this letter upon you, and I trust that you will accept it as a sincere attempt to discharge a not altogether pleasant duty.¹³⁷

Harris responded defensively but gave in.¹³⁸ Portal sent one more memo emphasizing the vital role of Germany's eastern Bergius plants and the USAAF's inability to bomb them during the short winter days. "That is why," he concluded, "you are asked to aim at the complete destruction of the plants."¹³⁹ Bottomley also sent Harris a memo reiterating that the USAAF could not deliver the required weight of attack. Only Bomber Command could carry out the required attacks and do the required damage. Consequently, he said,

¹³⁶ Harris's memo is at AIR 8/1745, Memo, Harris to Portal, 1 November 1944; Portal's reply is at AIR 8/1745, Memo, Portal to Harris, 5 November 1944.

¹³⁷ AIR 8/1745, Memo, Portal to Harris, 5 November 1944, 2.

¹³⁸ AIR 8/1745, Memo, Harris to Portal, 6 November 1944, 1-4.

¹³⁹ AIR 8/1745, Memo, Portal to Harris, 12 November 1944, 2. Emphasis in original.

no opportunity of attacking oil plants must be lost...The weight and density of attack of which your Command has shown itself capable, given adequate marking, far exceeds that normally achieved by the U.S. Air Forces. It is considered that one successful large scale concentrated attack by Bomber Command on an oil target should, on the basis of past experience, result in the long term immobilization of activity which is now required.¹⁴⁰

The upshot of this correspondence was a series of Bomber Command raids in the winter that knocked the distant Bergius plants out of action for the rest of the war.

In the meantime, the oil offensive continued at full tilt. Attacks during the first week of November, carried out using blind-bombing techniques, inflicted moderate damage on several oil plants and refineries.¹⁴¹ Despite these modest successes, virtually every CSTC bulletin from this period noted three frustrations: bad weather, short days, and the great distances to be covered during attacks on the eastern German Bergius plants.¹⁴² This troublesome trio made American daylight bombing of eastern German plants impossible, but it did not prevent the policing of western German oil plants and refineries, which were kept out of action. And reconnaissance pilots still brought in enough photographs to give BDA producers and the CSTC a good idea of damage done and rate of repair, as did the continuing stream of Ultra intercepts.

One of the most glaring fuel shortages had to do with efforts to move 6th SS Panzer Army to the Eastern Front. An intercepted note from the Germans' Director General of Armed Forces Transport emphasized the difficulty of moving units from the Western

¹⁴⁰ AIR 8/1745, Memo, Bottomley to Harris, 13 November 1944, 2.

¹⁴¹ MS16, S5, B8, F7, CSTC, "Combined Strategic Targets Committee, Working Committee (Oil Production), Weekly Bulletin No. 19," 7 November 1944, 1-2.

¹⁴² See, for example, MS16, S3, B4, F3, CSTC Target List, 16 November 1944.

Front to marshalling yards as a result of severe fuel shortages.¹⁴³ Equally troubling, in the East Army Group North said that

Since August 1944 there has been an acute shortage of liquid fuel of every description in Army Group Nord. As a result, operations by Panzer Troops and Air Forces have been temporarily reduced to a minimum. Only some 100 aircraft have been operating daily in the whole of the area of Army Group Nord during this period...Officers in charge of liquid fuel supply claim that this shortage in area of Army Group Nord is temporary, and that the crisis will have passed by January 1945 because, by that time, three new synthetic fuel works will have started to produce.¹⁴⁴

Ironically, Army Group Nord's assumptions all proved incorrect. They did not have time to rebuild their stocks as Russian attacks continued almost without pause, oil production was lowered even further by several additional rounds of air strikes, and the three new plants, which would have been small and dispersed as called for in the Geilenberg Plan, were never completed.

German POWs who served on the Eastern Front in the summer and early fall of 1944 and were captured in the West after their transfer there emphasized the disastrous fuel situation in the East. They noted that "the Russians encircled the Germans again and again, moving ahead faster than the Germans could retreat...Supplies were sent everywhere except where most needed. General chaos existed."¹⁴⁵ Another noted that "Gasoline is particularly lacking. In most instances supplies and artillery are moved by horse-power, therefore, very slowly. In addition to the gasoline shortage, Allied bombing of rail lines has further disrupted supply lines."¹⁴⁶ A German artillery officer claimed

¹⁴³ AIR 40/2073, AI3(e), "M.S.S. References to Oil Shortages and Restrictions since May 1944," 30 December 1944, 10 November intercept.

¹⁴⁴ Ibid., 17 November intercept.

¹⁴⁵ RG243, E36, B114, War Department, Captured Personnel and Material Branch, Military Intelligence Division, *Morale and Conditions in the German Army*, 13 December 1944, 2.

¹⁴⁶ Ibid., 4.

that it was necessary to demolish trucks and other vehicles due to a lack of fuel. Ultra intercepts and POW interrogations corroborated one another increasingly as fall turned to winter and the German fuel position continued to worsen.

Even more severe shortages continued to plague the Luftwaffe, which had received almost no new aviation fuel since August. An order given to all *Luftflotten* directed that there would be no night ground-attack sorties, no bombing missions, no transport missions except to isolated fortresses, and only 20 V-1 launches at a time. Operations were in general to be ruthlessly cut down and to take place only if weather and tactical considerations made success likely.¹⁴⁷ This order brings home just how absent the Luftwaffe had become even on the Eastern Front, where close air support and interdiction missions were now carried out only in periods of extreme need.

On 21 November, all German logistics units received a circular order issued to prevent fuel losses. Fuel trains were to be loaded and dispatched with maximum speed, and to travel at half capacity with a maximum load of 225 tons. They were to be brought up to the point at which a ban on rail traffic, brought on by air attacks, was in force. Until they could be sent forward or their contents offloaded at fuel depots, the trains' crews were to disperse fuel tanker cars at small train stations and camouflage them. Whenever possible, fuel was to be stored in tunnels. Only as much aviation fuel as necessary for combat operations was allowed at airfields.¹⁴⁸ These cumbersome requirements were part and parcel of the pervasive friction caused by Allied air attacks.

¹⁴⁷ AIR 40/2073, AI3(e), "M.S.S. References to Oil Shortages and Restrictions since May 1944," 30 December 1944, 18 November intercept.

¹⁴⁸ Ibid., 21 November intercept.

Of course, the intercepted order also told Allied intelligence officers how the Germans hid their fuel tanker cars, which then came in for even heavier air attacks.

And then there was the continuing saga of Panzer Lehr Division. During this unit's refitting in November, there was no fuel for maneuvers. New recruits, most of whom had never driven a tank or truck, thus had almost no training before they went into action during the Ardennes Offensive. The results were frequent accidents and high vehicle and crew losses. The division received its fuel increments just before the Ardennes Offensive and hid them in a railway tunnel. Beyerlein was promised five fuel increments but received two.¹⁴⁹ This, he surmised, might give his division 62 miles of movement. In fact, because muddy and snowy conditions doubled or even tripled fuel use, the range was only 40 miles.¹⁵⁰ The division had insufficient fuel during the move to the front and, as always, fighter-bombers singled out fuel trucks. Replacements expected on 25 December never arrived because they had no fuel. "Gasoline," Beyerlein said,

was getting short, and every drop of it had to be brought up from Troisdorf [a distance of over 100 miles] by truck. The long march had itself cost about 30 tanks aside from attacks—tanks which had bogged down, run out of gas, or had other mechanical trouble. About this time Model issued an order that all other stalled

¹⁴⁹ During a postwar interrogation, Albert Speer noted that many heavy divisions involved in the Ardennes Offensive had only one fuel increment. In this sense, ironically, Beyerlein's division was better off than most. See RG243, E31, B1, "USSBS Interview No. 11, Subject: Reichsminister Albert Speer," 31 May 1945, Minutes of interrogation conducted on 20 May 1945, 7.

¹⁵⁰ Earle Ziemke pointed out the much higher fuel-consumption rates in mud and snow. See his comments in *Stalingrad to Berlin: The German Defeat in the East* (Washington, D.C.: Office of the Chief of Military History, United States Army, 1968), 229, 232. So, too, did three senior German officers interrogated after the war—*Generalleutnant* Zimmermann (von Rundstedt's Director of Operations), *General der Kavallerie* Westphal (von Rundstedt's Chief of Staff), and *Oberst* John (von Rundstedt's Director of Logistics). They noted that during the Ardennes Offensive, "poor road conditions increased the consumption of fuel by 100 percent." In addition, due to fuel shortages, "Tank and truck drivers were insufficiently trained because of the drastically enforced fuel economy...a good many vehicles dropped out. The armored troops remembered bitterly the Senne-Lager where the economy of gasoline for training purposes was carried all too far." Fuel shortages on the Eastern Front created the same kinds of problems there. These comments are in Spaatz Box 134, HQ 12th Army Group, Interrogation Center, "Effects of US Strategic and Tactical Air Power," 12 June 1945, 9-12.

vehicles along the road should be drained of gas, which should be used to get the tanks up to the front.¹⁵¹

In the aftermath of the Ardennes Offensive, Bayerlein had to leave 53 tanks behind between 11 and 15 January as, one by one, they ran out of gas. Tanks in repair depots were drained of gasoline so tanks on the line would have a bit more in case tactical maneuvers were necessary.¹⁵²

The same set of cascading effects was at work here as had been the case in Normandy. Allied heavy and medium bombers destroyed marshalling yards, railroad bridges, and road bridges (first-order effects). This pushed the railheads back 100 miles (second-order effects), which forced division commanders to use their trucks as supply haulers rather than troop transports, thus demotorizing their units (third-order effects). Ironically, the long supply runs increased gasoline usage substantially (fifth-order effects). Despite these efforts, fuel and ammunition supplies remained notoriously unreliable and inadequate (sixth-order effects).

In the case of heavy units moving towards the front, the destruction of marshalling yards and major road and rail bridges (first-order effects) forced units to road march from 100 to 250 miles and sometimes even more to get in position for the attack (second-order effects). This forced units to consume their fuel increments, which were intended for tactical maneuver, with little likelihood of recouping these stocks once on the line (third-order effects). In addition, the long road marches caused severe wear and tear on armored vehicles, which often arrived at the front in poor condition (fourth-order effects).

¹⁵¹ MS16, S5, B12, F10, 9th Air Force APWIU, "A Crack German Panzer Division and What Allied Air Power Did to It between D-Day and V-Day," 29 May 1945, 16.

¹⁵² Ibid., 20-21. The full telling of this calamity is on pages 11-21.

Fighter-bomber attacks also took their toll as units approached the front (fifth-order effects).¹⁵³ Finally, divisions had to split up and take different routes to the front, losing their cohesion as well as much of their combat power (sixth-order effects). At each level in this assembly of cascading effects, friction was always at work.

Bayerlein emphasized that, as in Normandy, there was “almost always a shortage of fuel,” which made the following basic tactical actions difficult or impossible: the movement of tanks for counterattacks, changing the position of the division’s artillery, bringing up reinforcements, moving reserves to endangered sectors of the front, hauling tanks to repair shops, bringing forward fuel and ammunition, and conducting mobile defensive operations.¹⁵⁴

The Japanese Naval Attaché, too, kept up his stream of reports to Tokyo. He said Goebbels had assured him damage to the Reich’s oil industry was not as bad as the Allies said it was and that dispersal of the oil industry to underground plants was proceeding rapidly.¹⁵⁵ By this time, however, the attaché was not entirely trusting, so he met with German officers at the Admiralty and the Air Ministry, who said that construction of underground oil refineries was “very much behind schedule” and that even though the production of aircraft had been a success, the lack of fuel had undermined the Luftwaffe’s operational capability. Pilots, they said, were “complaining bitterly of

¹⁵³ Tanks were not designed to make extended road marches. The German answer to this problem was to move tanks to the railheads and then by road to the front. However, because Allied air attacks pushed the railheads back so far, the Germans were forced to move their tanks by road much further than anticipated.

¹⁵⁴ Ibid., Appendix I, page 4.

¹⁵⁵ AIR 40/2073, “References to the Oil Offensive in ‘ULTRA’ Information,” January 1945, 9 November intercept.

boredom in the mountains of Central Germany.”¹⁵⁶ The attaché concluded: “I was... able to see that oil is the most critical problem with which Germany is now confronted.”¹⁵⁷

Even with the good news, Bufton and Maxwell did not rest on their laurels. Although 10 of 11 western synthetic oil plants were inactive, in central and eastern Germany five of 11 plants were active and the others were probably active. Even worse, they would produce 180,000 tons of oil in November and could increase that to 240,000 tons in December if not successfully attacked before then. Most of the Austrian, Czechoslovakian, and Polish refineries were in production. Finally, of 23 major benzol plants in the Ruhr, 14 were fully active.¹⁵⁸ Production estimates were 449,000 tons (34 percent of pre-attack total) in November and 565,000 tons (42 percent) in December.¹⁵⁹ This pointed to an alarmingly rapid resurgence in oil production.

The news was not all bad, though. Not only were the Ruhr oil plants out of action and now to be “policed” only as needed by Bomber Command; Mr. Lawrence also noted that the rate of repair of Ruhr oil plants had been slower than expected, theorizing that rapid repair capability declined as a plant received progressive damage, leading at some point to a situation in which only major structural repairs could get a plant up and running again. The Allies confirmed this in postwar ground surveys.¹⁶⁰ In addition, earlier

¹⁵⁶ Ibid., 2 December intercept.

¹⁵⁷ Ibid.

¹⁵⁸ MS16, S5, B8, F7, CSTC, “Combined Strategic Targets Committee, Working Committee (Oil Production), Weekly Bulletin No. 21,” 21 November 1944, 2-6.

¹⁵⁹ MS16, S5, B8, F7, CSTC, “Combined Strategic Targets Committee, Working Committee (Oil Production), Weekly Bulletin No. 22,” 28 November 1944, 1.

¹⁶⁰ AIR 2/8011, Minutes, CSTC 6th Meeting held on 22 November 1944, 27 November 1944, 3-5. In a postwar interrogation, Albert Speer confirmed that cumulative structural damage made oil plants increasingly difficult to repair. He said “It was essential to continue the attacks on synthetic oil plants up to the end of the war. At first it was possible to start a plant up again within six or eight weeks after an attack, thanks to our repair measures... Several attacks on the same plant considerably weakened its structure (gas and water mains) and consequently towards the end of the war an equal weight of attack lengthened the

estimates of oil production proved too high. Even when the Germans got their oil plants back on line more quickly than expected, output was often only 25 percent or less of capacity. A JIC report noted that production totals were at most 400,000 tons in October (30 percent of pre-attack capacity) and 450,000 tons (34 percent) in November. Also, the former head of the German oil administration in Bucharest, now in Russian hands, corroborated Allied assessments that the Germans had at most a month of oil reserves remaining. "The problem of providing petroleum," he concluded, "has become the central problem in the Reich."¹⁶¹ Finally, a report produced by Allied oil experts concluded—properly, as postwar interrogations proved—that the effort to disperse oil refineries to small towns or underground would not bear fruit for two years.¹⁶²

Even more ominous for the Germans was the start, at long last, of Bomber Command night precision raids against the distant Bergius plants. A 6-7 December attack on Leuna did serious damage. This raid involved the use of H2S Mark III for navigation to target and Pathfinder Force marking by 12 Mosquito aircraft in advance of the 475 Lancasters comprising the main force. Although post-strike cover did not arrive for several days due to poor weather, night-strike photo plots showed excellent concentration on the target despite considerable cloud cover in the area. Bomber Command crews had proven that precision night attacks on targets beyond the range of Oboe and Gee could work.¹⁶³

period which was required to restore production." These comments are located in AIR 20/8779, Control Commission for Germany, Field Information Agency, "Examination of ex-Reichsminister Speer—Report 26," 8, produced 13 August 1945. It was based on Speer's answers to a questionnaire entitled "The Effects of Allied Bombing of Germany," which he completed on 18 July 1945.

¹⁶¹ AIR 8/1018, JIC (44) 488 (O) Final, "Effects of Allied Attacks on the Enemy Oil Situation in Europe," 1 December 1944, 1-5. Emphasis in original.

¹⁶² AIR 2/8011, Minutes, CSTC 9th Meeting held on 13 December 1944, 15 December 1944, 3.

¹⁶³ MS16, S5, B8, F7, CSTC, "Combined Strategic Targets Committee, Working Committee (Oil Production), Weekly Bulletin No. 24," 12 December 1944, 3; Middlebrook and Everitt, *The Bomber Command War Diaries*, 628.

In addition, every time the Germans attempted to steal a march on the Allies by dispersing oil production or building new plants, reconnaissance aircraft and photointerpreters detected their efforts. For instance, Moosbierbaum, near Vienna, was now known to be an oil refinery and probably a processing plant for a high-grade distillate used to boost aviation fuel octane ratings. The refinery here was confirmed by reconnaissance cover and ACIU D Section reports to be the same one dismantled by the Germans at Port Jerome in France in anticipation of rebuilding it in the Caucasus to refine crude oil. Records obtained after the liberation of France reconfirmed this. The estimated output of the equipment installed at Moosbierbaum was 150,000 tons per year, and its production of high-grade distillates made it even more important. Within days, 15th Air Force bombers attacked the plant. This was one of a number of raids made in a rare good-weather period in which, a CSTC report noted, "Good progress has therefore been made towards the precipitation of a fresh crisis in the German oil position..."¹⁶⁴

In fact, progress was much better than the CSTC had thought possible, based on the start of Bomber Command night precision raids and better-than-expected blind-bombing results. The latest attacks had driven output to less than 100,000 tons per month, almost all of which was now coming from six plants: Sholven, Zeitz, Böhlen, Lützkendorf, Magdeburg, and Ruhland. Even allowing for the maximum recovery of damaged plants and assuming no more attacks, January production would not exceed 210,000 tons. Reconnaissance cover of 24 December showed Brück out of action for a short period; Leuna out of action with major damage to two of the three injector houses and other

¹⁶⁴ MS16, S5, B8, F7, CSTC, "Combined Strategic Targets Committee, Working Committee (Oil Production), Weekly Bulletin No. 25," 19 December 1944, 2-3, 7.

sections of the plant, rendering it inactive until at least early January; Pölitz out of action with damage to the main boiler house and a return to production within two weeks; and Blechhammer North out of action for several weeks. As a CSTC report concluded:

Having regard to the severely damaged condition of some of the inactive plants, therefore, synthetic oil production as a whole is in a more fragile condition than ever before...The overall situation is now again comparable to the position achieved in mid-September, with the significant difference that its susceptibility to a knockout blow has greatly increased.¹⁶⁵

The report closed with a revised production estimate for December: 409,000 tons (30 percent of pre-attack capacity). As another CSTC report released in the same timeframe noted, presciently as it turned out, if the six major Bergius plants still in operation could be knocked out, "the enemy will be confronted with the most acute POL supply situation which he has yet had to face and this will be further aggravated should large scale offensive action be resumed by the Russians on the Eastern Front."¹⁶⁶ Of course, the Führer himself contributed to this threat of operational catastrophe by committing the German military to the Ardennes Offensive, which consumed *half* of all German fuel produced in November and December while at the same time making it impossible for German armies in the East to rebuild their depleted fuel stocks.¹⁶⁷ Indeed, the Germans launched their attack with only *one or two* fuel increments for each of their heavy divisions, rather than the standard five, even with this huge diversion of fuel from the more important Eastern Front. To make matters worse for the German war effort, a mere eight targets—six synthetic oil plants and two major crude oil refineries—were all that

¹⁶⁵ MS16, S5, B8, F7, CSTC, "Combined Strategic Targets Committee, Working Committee (Oil Production), Weekly Bulletin No. 26," 26 December 1944, 1-2.

¹⁶⁶ MS16, S3, B4, F3, CSTC Target List, 28 December 1944, 5.

¹⁶⁷ RG243, E31, B1, "USSBS Interview No. 11, Subject: Reichsminister Albert Speer," 31 May 1945, Minutes of interrogation conducted on 20 May 1945, 7.

stood between the last vestiges of German battlefield mobility and cataclysmic fuel shortages. The cataclysm was not long in coming.

The Ardennes Offensive, although it shook the Allied leadership, was a calamitous affair for the German army, which had to make due with a fraction of the fuel available just 10 months earlier and did so in distinctly unfavorable tactical conditions. The plan had been to capture American fuel dumps and use the gasoline so obtained to continue the offensive. The Germans did not capture a single one. Because armored units had only one or two fuel increments and had to advance over muddy or snow-covered terrain, which drove up gasoline use alarmingly, their ability to maneuver was compromised. We have seen how this affected Panzer Lehr before and during the Ardennes Offensive. Another unspecified division refitting prior to the offensive had similar problems. A prisoner from this unit said there had been no gasoline at all prior to moving to the railroad station to entrain for the Ardennes Offensive. Each vehicle had five liters (1.32 gallons) of fuel, which was too little for the journey to the station. Consequently, over half the division's vehicles, including its half tracks, ran out of fuel prior to reaching the station and had to be towed the rest of the way by wreckers. Many of the halftracks and trucks, just delivered from the factories, broke down and needed complete overhauls, or had to be written off entirely, because the five-liter fuel allocation had not been enough to run-in their engines. Most of the drivers had received no training due to lack of fuel, so even vehicles that were operational at the start of the offensive were often wrecked in traffic accidents. The operational costs of fuel shortages were high indeed.¹⁶⁸

¹⁶⁸ Spaatz Box 127, MEW, "M.E.W. Intelligence Weekly, Report No. 152," 4 January 1945, 2.

In the meantime, German heavy divisions on the Eastern Front—which outnumbered those in the West three to one—had to make due, as did units in Italy, with the other half of gasoline production for the last two months of 1944.¹⁶⁹ Consequently, they were unable to rebuild their fuel reserves and had far too little gasoline once the Russian winter offensive, which took the Germans completely by surprise, got underway. Viewed in this light, Allied bombing held German fuel production at a level low enough to hamper the Ardennes Offensive and, even more importantly, deny German divisions in the East an opportunity to rebuild their fuel reserves. In fact, the oil offensive had already combined with an ineffective and poorly structured German logistical system to create disastrous fuel shortages on the Eastern Front as early as September 1944. As we will see in the next chapter, this produced an operational cataclysm for the German army, shortening both the war's duration and the Allies' casualty lists.

¹⁶⁹ Of 344 German divisions in the field in April 1944, 205 (59.5 percent) were on the Eastern Front, including 37 of the 57 Panzer and Panzer Grenadier divisions (64.9 percent). The totals in the West were 56 divisions (16.3 percent) and eight Panzer and Panzer Grenadier divisions (14.0%). These proportions remained largely unchanged with the exception of the Ardennes Offensive, during which the number of heavy units in the West increased, but reverted to the norm once again with the start of the January 1945 Russian offensive in Upper Silesia. See MS16, S5, B12, F4, HQ SHAEF, "Commanders Weekly Intelligence Review No. 4," 30 April 1944, 1.

CHAPTER 11

ENDGAME: BDA, THE FINAL DESTRUCTION OF THE REICH'S OIL AND TRANSPORTATION ASSETS, AND THE DEFEAT OF THE WEHRMACHT

*There are two basic principles governing the aims of the war. One principle, according to Clausewitz, has as the aim of the war the direct destruction of the fighting forces of the opponent. Opposed to this is the Anglo-Saxon principle that the fighting forces of the opponent must be eliminated indirectly by the destruction of the opponent's industry...this [second] principle will be the deciding factor for us even after the destruction of our opponents in the east.*¹

-Dr. Kurt Tank, President of Focke Wulf Aircraft Company, to Generalfeldmarschall Erhard Milch, July 1942

*Your intelligence service must have been very efficient because, no sooner was a synthetic oil plant in working order again than you appeared two days later and destroyed it once more. Those were the things which were bound to bring us to our knees.*²
- Generalfeldmarschall Erhard Milch

*It was universally agreed that we should pursue oil to the last drop.*³
- Combined Strategic Targets Committee, 25 March 1945

*We are now hardly able to fill our cigarette lighters.*⁴
- Joseph Goebbels, Diary, 2 March 1945

11.1 Transportation Attacks on the Third Reich: Decisive, Flawed, or Both?

The air campaign against the Third Reich's railroads and inland waterways was the last and largest of the offensives against Germany's war effort. Its impact on the Reich's

¹ Spaatz Box 272, USSTAF A-2, *The Contribution of Air Power to the Defeat of Germany*, 1 August 1945, Volume 1, Section 4, 1.

² Spaatz Box 134, CSDIC (UK), Interrogation Report CS/2126, "Generalfeldmarschall Erhard Milch," 23 May 1945, 3. Emphasis in original.

³ AIR 2/8011, Minutes, CSTC 23rd Meeting held on 21 March 1945, 25 March 1945, 8.

⁴ Hugh Trevor-Roper, ed., *Final Entries 1945: The Diaries of Joseph Goebbels*, trans. Richard Barry (New York: G. P. Putnam's Sons, 1978), 27.

war industry as well as its armies and air forces was catastrophic. In his classic study, *The Collapse of the German War Economy, 1944-1945*, Alfred Mierzejewski characterized attacks on railroads and inland waterways as a decisive if flawed employment of airpower in an effort to shorten the war and Allied casualty lists. The effort was decisive, he said, because it worked. It was flawed, he continued, because it got into high gear too late as the result of poor targeting recommendations by the CSTC and a lack of clarity about the effects of bombing on transportation assets.⁵

The United States Strategic Bombing Survey (USSBS) agreed, noting that

The attack on transportation was the decisive blow that completely disorganized the German economy. It reduced war production in all categories and made it difficult to move what was produced to the front. The attack also limited the tactical mobility of the German army.⁶

It also noted the same flaws Mierzejewski later pointed out in his work:

[T]he very serious declines in traffic movement which had been imposed by the end of 1944 were not recognized and the strength of the system as of that date was overestimated. Had the effectiveness of the attacks been fully recognized they might have been pressed home in a more systematic fashion, producing an earlier collapse of the railroad system.⁷

The transportation offensive was effective despite these BDA shortcomings. Freight cars loaded in the Reich totaled 900,000 for the week ending 19 August 1944. From there the total dropped to 700,000 per week by 31 October. A further drop to 550,000 by 23 December was followed by a catastrophic decline to 214,000 by 3 March 1945. Attacks on inland waterways were even more successful. The Dortmund-Ems and Mittelland Canals were closed by bombing raids on 23 September. Barge traffic on the Rhine and in

⁵ Alfred C. Mierzejewski, *The Collapse of the German War Economy*, 177-187.

⁶ MS16, S5, B12, F14, *The United States Strategic Bombing Survey Summary Report (European War)*, 30 September 1945, 12.

⁷ SMS347, Addendum 1, B13, USSBS Transportation Division, *The Effects of Strategic Bombing on German Transportation*, 20 November 1945, 5.

the Ruhr was constantly interdicted by October. The commodity most affected by these disasters was coal. It became impossible to move this lifeblood of the German economy, as Mierzejewski described it, by water, and nearly impossible to do so by rail after November. The results were disastrous for industry and for the *Reichsbahn*, whose coal stocks declined from an 18-day supply in October to a 4.5-day supply in February.⁸

In addition, this transportation catastrophe hit the German war economy especially hard because component parts produced at dispersed factories could not be moved expeditiously to central assembly points. The progressive disorganization and destruction inflicted on the Reich's marshalling yards also made the movement of weapons, ammunition, and fuel very difficult. The result, when combined with an already inefficient logistical system, was a situation in which armies and air forces in the field often failed to receive the replacement weapons, ammunition, and fuel necessary to engage in large-scale maneuver warfare. Finally, the transportation campaign acted synergistically with the oil offensive to produce a number of vital but often unlooked-for effects on the German war effort, a crucial issue we will examine later.

In view of these disastrous impacts on the German war economy and operations in the field, we might be tempted to conclude that the transportation offensive against the Third Reich, and the targeting and BDA efforts underpinning it, were as effective as the oil offensive. Yet this was not the case, in no small measure because air intelligence support to this final campaign was less effective. The reasons for this, which Mierzejewski addressed, and which we will reexamine here, were a product of three major problems. The first was the inherent complexity of transportation attacks

⁸ Ibid., 13-14.

themselves, which involved not only military-strategic attacks on the movement of coal and hence on the German war economy, but also deep interdiction strikes on marshalling yards and bridges as well as close interdiction, both of which were designed to reduce the volume and speed of arrival of German reinforcements, weapons, ammunition, and fuel to the fighting fronts. The complex interplay of demands for these three types of attacks, which was itself a product of the vicissitudes of the ground campaigns in the West and East, had a “whipsaw” effect that pulled heavy bombers from one kind of attack to another as the situation demanded. The second problem had to do with bureaucratic infighting among Allied intelligence agencies, which either favored transportation attacks and, by extension, either a military-strategic or operational-tactical focus for those raids, or oil attacks. This preference for oil was the third issue affecting the degree of effort and focus brought to transportation attacks. Most airmen saw oil attacks as the best target for undermining the German war effort and ending the war quickly, so they had priority.

The most notable exceptions were Tedder and Zuckerman, who believed that a concerted attack on the Third Reich’s railroads and inland waterways promised a rapid collapse of the German war economy and by extension of her armies and air forces in the field. Proponents of the oil-first approach, including Spaatz and Bottomley as well as Bufton and Maxwell (the CSTC Co-Chairmen), won the argument, and oil remained the top-priority target. Nonetheless, it would be a serious error to dichotomize this problem. It was not as if the primary emphasis on oil drove a fatal reduction in transportation attacks. In fact, as the weather worsened in the fall of 1944, German transportation assets received a much greater share of bombs than did oil targets. Of 2,697,473 tons of bombs dropped on Axis targets, 36.3 percent went to transportation targets and 11.1 percent to

oil.⁹ The reasons for this were twofold. To begin with, transportation targets had second priority after oil and were the default targets if weather conditions prevented bombers from engaging oil targets. In fact, bomber crews had standing orders to attack rail centers, regardless of weather conditions, with Gee-H, Micro-H, H2S Mark III, or H2X. Also, the much greater number of transportation targets required more sorties and bombs.

A related and absolutely vital point often overlooked by scholars, and one largely ignored by Mierzejewski, was the synergy between transportation and oil attacks. In fact, Mierzejewski makes only three references to the oil offensive in *The Collapse of the German War Economy*, which together amount to less than a single page of text.¹⁰ For someone convinced, as he was, that transportation attacks paid greater dividends than oil attacks and should have had higher priority, this omission undermines his argument. The heavy-bomber campaigns, devoted to oil *and* transportation attacks, created synergistic effects dramatic in their impact on the German war effort and often unlooked-for even by intelligence officers making targeting recommendations and assessing the effects of air attacks. We have seen the strong synergy between transportation and oil attacks during the campaign in Normandy and the subsequent breakout and pursuit across France. Similar synergies developed as the oil offensive intensified and transportation attacks began in earnest by fall 1944. Together, they proved cataclysmic for the German war effort. One example of several we shall examine was the effect on fuel and ammunition production and distribution. The oil offensive destroyed synthetic oil plants, robbing the Germans of fuel *and* of explosives and propellants, which depended on the nitrogen and

⁹ SMS347, Addendum 1, B13, *The United States Strategic Bombing Survey Over-all Report*, 30 September 1945, 2, Chart 1.

¹⁰ These references are on pages 2, 181, and 208 note 40.

methanol made at oil plants as by-products of oil production. Added to the much lower production was a further interaction between transportation attacks and a cumbersome manufacturing process in which ammunition components such as shell casings and fuses, and explosives and propellants, were produced in different areas and then shipped to over 100 German army ordnance depots for final assembly. This inefficient process was highly vulnerable to transportation disruptions and resulted, along with attacks on synthetic oil plants, in a catastrophic drop in German ammunition production.¹¹

It was against this backdrop of strategic, operational, and bureaucratic factors that the transportation campaign against the Reich's railroads and inland waterways was conceived, debated, and carried through to a successful if less than optimal conclusion, and in which the oil campaign was brought to a dramatically successful conclusion. Together, these two relentless attacks on Germany's most vital military and economic assets—transportation and oil—were instrumental in the rapid collapse of German resistance during the spring of 1945.

11.2 Targeting Railroads and Canals: Tedder's Transportation Plan

As the transportation offensive against French and Belgian railways reached a crescendo in the late summer of 1944, and as the oil campaign began undermining the German army's ability to mass and maneuver, Tedder was at work on a new transportation plan targeting the Reich's railroads and canals. As ever, Zuckerman worked with him, bringing to bear the ground survey reports and captured railway records, French and German, flooding into his Bombing Analysis Unit offices. They

¹¹ See SMS347, Addendum 1, B13, *The United States Strategic Bombing Survey Over-all Report*, 30 September 1945, 51-58, for a detailed description of this process.

used these sources to make the case for an all-out assault on Germany's transportation networks. Released under Tedder's signature on 25 October, the plan called for the complementary and synergistic employment of air and ground forces. Tedder said:

In my opinion our primary Air objective should be the enemy's communications. Road, water, and rail are interdependent and complementary, and our Air operations should play on that fact. The present Oil Plan is the key to movement by road and air, and, moreover, directly affects operations in the battle area...It is abundantly clear from French and German railway records (the latter kept with typical tidy thoroughness) that:

- a. It was the heavy attacks on rail centres and marshalling yards which were the main factor in paralyzing the rail system in northern France, and
- b. The effect of these attacks was far more rapid and final than had ever been anticipated.¹²

This confident statement was built on the firm foundation provided by BDA reports produced during and after the transportation offensive against railroads in France and Belgium. It also came from Tedder's recognition that transportation and oil attacks had been highly synergistic in France and would likely be so once again in the Allied air and ground assault on the Reich.

However, Tedder emphasized that Allied airmen must not equate earlier efforts with the impending attack on German transportation assets. "In Germany," he noted, "all loss of traffic is a dead loss to the war effort."¹³ He further noted that manpower and materials for the repair of railroads were in short supply. Accordingly, Tedder recommended simultaneous attacks on rail centers, oil targets, and canal systems. This coordinated and concerted campaign was to be carried out by heavy and medium bombers, and by fighter-bombers, as had occurred in France:

¹² AIR 8/1745, Tedder, "Notes on Air Policy to be Adopted with a View to Rapid Defeat of Germany," 25 October 1944, 1-2.

¹³ Ibid., 2. Emphasis in original.

The Tactical forces' operations against trains, embankments, selected bridges, etc., will then be complementary to the strategic operations, and will continue with a far greater prospect of producing immediate effect...The Combined Strategic and Tactical Air Forces will, in fact, be operating towards one objective...the execution of a coordinated campaign against the communications system of western Germany such as I have outlined would rapidly produce a state of chaos which would vitally affect not only the immediate battle on the West Wall, but also the whole German war effort.¹⁴

Tedder produced his paper with Zuckerman's assistance the day after a contentious meeting at the Air Ministry in which senior operations and intelligence officers discussed the possibility of forcing a German collapse within 90 days by carrying out heavy raids on transportation assets. Mr. Brant of the RRS was adamant that such a plan could not succeed, especially given the approaching bad weather and short days of winter. He and the other experts at the meeting recommended concentrating on lines of communication west of the Rhine to cause the maximum delay and disruption of German troop and supply movements.¹⁵ As we saw in the previous chapter, Ike pressed his subordinates to develop a transportation campaign that would produce a German defeat by the end of the year. Bufton and Maxwell succeeded in convincing him that a continued emphasis on oil would pay the biggest dividends, an argument he accepted, although not without demanding that a more modest transportation effort nonetheless proceed.

Tedder and Zuckerman were dissatisfied with these decisions, which placed the emphasis on oil attacks while relegating transportation attacks to a *subordinate and operational role* focused on impeding the movement of German troops and supplies west of the Rhine, rather than the *superior and military-strategic role* they thought such

¹⁴ Ibid.

¹⁵ AIR 8/1745, Minutes, "Summary of Statements by Railway Experts at Meeting Held at Air Ministry, Whitehall, on 24th October, 1944, to Make a Preliminary Review of the Enemy Transportation Position," 26 October 1944, 1.

attacks should play. Indeed, they pushed from the outset for a transportation campaign that would destroy both railroads and canals, in the process undermining the German army's ability to mass and maneuver, but more importantly destroying the German war economy itself—one of the two foundations upon which all military operations depended.¹⁶ During the next few weeks they argued tirelessly for such a campaign.

There is, however, one important caution as we consider these developments. Too much has been made of the differences between Tedder's position and that taken by CSTC members, who held that oil attacks should continue to have primacy. For one thing, Tedder never approached the problem from an either-or perspective. As he noted in his draft transportation campaign plan, the oil offensive was undermining German mobility at the fighting fronts. Further, he stated explicitly that the synergy between oil and transportation attacks demanded that the Allies press forward with both. His argument was simply that transportation attacks had the potential to undermine the German war effort at its sources of supply—the coalfields of the Ruhr and the arms factories that depended on them for fuel—and thus at the fighting fronts. Oil attacks, he said, would make this process more effective but should not proceed on their own.¹⁷

¹⁶ As Tedder recognized, the other and equally important foundation was oil.

¹⁷ In his classic study of the transportation campaign against the Third Reich, Mierzejewski provided an outstanding look not only at the campaign itself, but also at the planning for it. In fact, his work, dedicated entirely to the transportation offensive, provides much greater detail than we can hope to include in this broad survey of BDA capabilities. However, Mierzejewski too starkly painted the differences between Spaatz and the co-chairmen of the CSTC, who supported the oil offensive; and Tedder and Zuckerman, who pushed for the transportation campaign against the Reich. Consequently, he framed the issue within an either-or context, something neither Tedder nor Spaatz ever did. Tedder, as we have seen, did not push for transportation attacks at the expense of oil attacks, but rather as a complementary effort, albeit one he thought should have higher priority. Mierzejewski also argued that the oil offensive produced *tactical and operational effects* at the fighting fronts while transportation attacks had the potential to produce *military-strategic effects* by undermining the German war economy. Clearly, then, he saw the latter as more important to the German war effort. However, what we have thus far seen of the oil offensive's impact on the German military (and shall discuss at greater length later in this chapter) makes it obvious that even

The upshot of this disagreement was Bottomley's decision, with Spaatz's concurrence, to set up a new CSTC Working Committee (Communications) to provide target priorities and a weekly targets list for the attack of key transportation assets in Germany. The committee included transportation experts from the RRS, SHAEF, the War Office, the Air Ministry (A.I.3.e), MEW, and EOU. Aside from issuing weekly prioritized target lists and reports on the progress of transportation attacks, the members of this working committee (which was the direct descendant of the Railway Targets Committee set up to support Overlord) were to work up a preliminary transportation plan and list of targets under the direction of Mr. Brant.¹⁸

The three most important developments growing out of the 24 October meeting to discuss the possibilities for a transportation offensive against the Reich were therefore Ike's approval of a continued emphasis on oil attacks, Tedder's dissenting opinion as noted in his draft plan for a major transportation offensive against the Reich, and the formation of a new CSTC Working Committee (Communications) to address the various issues surrounding transportation attacks on the Reich.

Tedder and Zuckerman based their plan for the destruction of Germany's transportation assets not only on an intuitive grasp of the problem but also on BDA reports that underscored the degree to which transportation attacks in France and Belgium had produced a ripple effect on coal and steel production in the Ruhr. Because bombing

without the collapse of Germany's war industry in the winter and spring of 1945, *there would have been almost no fuel* for the armored vehicles, trucks, and aircraft coming off the assembly lines or those already in the field. The calamitous fuel shortages in the Luftwaffe by late summer 1944, and in the German army by fall 1944, made this point with absolute clarity. A concerted attack on transportation networks did indeed cause the collapse of the German war economy, as Mierzejewski expertly made clear, but by then fuel shortages had already undermined the German war effort. For Mierzejewski's argumentation, see *The Collapse of the German War Economy*, 84-101.

¹⁸ AIR 2/8011, Memo, Bottomley to Tedder (copy to Spaatz), 29 October 1944, 1-2.

raids on Hamm and other marshalling yards in western Germany had caused severe damage, coal stocks at the mines had increased by 400-500 percent as too few trains arrived to carry the coal away. Steel production fell in turn. To make matters worse for the *Reichsbahn*, bad weather in September and October meant that transportation targets, which had second priority after oil, received two-thirds of the total bomb tonnage. The end result was a major coal famine throughout the Reich.¹⁹

Once again, Ultra intercepts gave air intelligence officers very useful insights on the damage bombers were doing to German transportation assets even before any systematic attack on the Reich had begun. On 19 October, Army Group B made an urgent request for a greater use of Rhine River ferries since Allied bombing had already dropped most road and railroad bridges.²⁰ The following day, the Reich Minister for Equipment and

¹⁹ Mierzejewski, *The Collapse of the German War Economy*, 89, 93, 103. Mierzejewski, who quite properly noted these disastrous effects of Allied bombing on German transportation and therefore on the movement of coal, in the process contradicted a statement he made earlier in his work. On page 68, he said, "The power of the forces at their disposal by the spring of 1944 was not understood by the Allied bomber commanders... They fought to concentrate their forces against a limited number of target systems and objectives. In doing so they underestimated what their forces could do." All the evidence indicates that exactly the opposite was true. Allied senior airmen understood very well the power at their disposal, and they chose to deploy it with remarkable discipline and determination against the two target sets they knew to be at the heart of the German war effort: transportation and oil. There was relatively little dissipation of effort on less important targets, and the fact that transportation targets were second priority immediately after oil meant that if weather conditions made large-scale attacks on oil plants and refineries impossible, Allied bombers went after marshalling yards. Mierzejewski also erred in his statement that intelligence concerning the German war economy was abundant but of varying quality. "The crucial factor," he said on page 70, "in determining exploitation of this intelligence was not its content but the preconceived notion brought to it by the analysts and the ability of intelligence organizations to function effectively in the highly bureaucratic-political environment surrounding the air decision makers." This assertion flies in the face of all the evidence, particularly in the case of oil, which the Allies had been watching very closely for years. What is striking is not the infighting, which was *de rigueur*, but the convergence of opinions on both oil and transportation attacks during 1944.

²⁰ AIR 40/2658, A.I.3.(e), "Extracts from CI/MSS giving the effects of air attacks on German Communications, as from 1.10.44," 28 February 1945, 1, intercept T.342/37 of 19 October 1944. There is an important caveat to be added regarding these Ultra intercepts. Mierzejewski claimed on page 167 of *The Destruction of the German War Economy* that Ultra intercepts were not only ignored but actively suppressed by the CSTC. He also implied that in consequence of this CSTC duplicity, Ultra intercepts were either overlooked altogether or in large measure within Allied targeting activities and policy. While Mierzejewski's argument about the CSTC's having ignored or missed the importance of Ultra messages

War Production said the destruction of rail centers and power plants had brought 30-35 percent of war industry to a standstill.²¹ The same day, C-in-C West confirmed that the road suspension bridge at Cologne-Mühlheim, raided on 14 October, had fallen into the Rhine River and blocked all barge traffic.²² To make matters even worse, an attack on the Mittelland Canal near Minden on 26 October destroyed a 100-foot section, bringing canal traffic to a standstill. The ensuing flood destroyed two factories and brought rail traffic at the key junction of Bielefeld to a standstill for two days.²³ These intercepts

dealing with transportation attacks has merit, available evidence indicates that his accusations about its having actively suppressed Ultra intelligence are baseless. It is no secret that the CSTC viewed oil as the most important target and transportation as secondary, but there is equally clear evidence that CSTC representatives arrived at these conclusions based on the dramatic impact of the oil offensive in the late summer and fall of 1944, not as the result of some deeply ingrained and irrational prejudice against transportation targets. It is also important to remember that Allied ground commanders wanted concerted heavy-bomber raids against marshalling yards supporting German military operations at the fighting fronts. This in effect diverted a large proportion of available sorties from economic-strategic attacks on coal shipments and war production, to tactical-operational sorties in support of Allied ground forces. Ironically, SHAEF was one of the guilty parties in this process. While SHAEF G-2 (Intelligence) called for attacks on coal shipments and hence on the German war economy, SHAEF G-3 (Operations) demanded frequent attacks in support of the ground advance. Finally, there is no doubt that senior American and British airmen, Spaatz and Bottomley included, were seeing at least some and probably most of the more important Ultra messages relating to both oil and transportation attacks, which the Special Security Officers on their staffs would have flagged as worthy of their chiefs' review. The CSTC worked for Spaatz and Bottomley, not the other way around, and made target *recommendations* to them. Had either Spaatz or Bottomley felt something was seriously amiss in the CSTC, or that its targeting recommendations were fundamentally flawed, they would have addressed the problem. There is no indication they ever felt a need to do so. In fact, Bottomley and Spaatz ordered a detailed review in February 1945 of Ultra intercepts relating to the transportation offensive, both to reevaluate Allied air strategy in the wake of the Ardennes Offensive and to determine how best to employ heavy bombers during the spring of 1945. Based on their findings, *they chose to make no changes to the Allied bombing directive then in force* (Directive 3, promulgated on 20 January 1945), which gave oil targets top priority. In fact, oil targets maintained their position of primacy until April 1945, when "Draft Directive 4 for Strategic Air Forces in Europe" gave top priority to direct support of the land campaign. This directive was never promulgated but Allied senior airmen understood and followed its guidance. See AIR 8/1745, COS (45) 61, "Revised Directive for Strategic Air Forces in Europe" (Directive 3), 20 January 1945 and AIR 8/427, "Draft Directive 4 for Strategic Air Forces in Europe," 16 April 1945. In addition, given Bufton's and Maxwell's close relationship and affinity of thought about the bombing effort with Portal, Arnold, Bottomley, and Spaatz, it seems highly unlikely that they would have actively suppressed intelligence of value to their superiors and, by extension, to Allied bombing. We must therefore view the CSTC's failings in this regard as the result of misjudgment rather than part of some larger plot to suppress information.

²¹ AIR 40/2658, A.I.3.(e), "Extracts from CI/MSS giving the effects of air attacks on German Communications, as from 1.10.44," 28 February 1945, 2, intercept T.347/46 of 20 October 1944.

²² Ibid., intercept T.353/25 of 20 October 1944.

²³ Ibid., intercept T.357/90 of 27 October 1944.

provided utterly reliable and near-real-time intelligence that gave Tedder and other officers a clear understanding that a systematic campaign against the Reich's transportation networks could do grievous harm to the German war effort, particularly in conjunction with the oil offensive.

There was more bad news in store for the Germans. Although H2X offered a poor choice for bombing the Ruhr's railroads and canals, Gee-H beacon stations were now operational on the Continent, allowing for accurate bombing of Ruhr targets in non-visual conditions.²⁴ Although Gee-H was by no means perfect, it allowed heavy bombers to put an adequate number of bombs on their targets often enough to cause serious damage to rail centers and consequent delays in the movement of fuel, ammunition, and reinforcements to the front. It also helped to disrupt the flow of component parts from dispersed factories to central assembly points. Finally, this ability to bomb during bad weather played havoc with the movement of coal from mine to factory.

On 7 November, the CSTC Working Committee (Communications) unveiled its plan for the attack on German transportation assets. It was designed to provide the maximum assistance to military operations on the Western front; assist operations on the Eastern and Italian fronts; and, in line with Tedder's draft plan, exert maximum pressure on war production by interfering with economic traffic. This plan was not what Tedder wanted, but it did provide for concerted attacks on coal shipments. Because Bottomley and Spaatz had decided, in view of the dramatic success of oil attacks, to make transportation attacks second priority, the CSTC's recommendation was to conduct attacks on marshalling yards when weather conditions did not permit visual bombing of oil targets.

²⁴ Spaatz Box 84, Memo, Maxwell to Anderson, 10 October 1944.

The German transportation system, they noted, was difficult to interdict and would require concerted attacks even during periods of bad weather. Finally, the CSTC noted that oil attacks against targets in the Ruhr were synergistic because they also damaged railroads, roads, canals, and the natural gas grid feeding Ruhr industries.²⁵

The CSTC plan was built almost entirely on lessons learned from the recent transportation campaign in France. "Experience in Northern France," it noted, "showed that recovery of rail traffic is fairly rapid unless steady continuous pressure is maintained against all major centres of the system under attack."²⁶ The working committee emphasized the importance of coordination between heavies, medium bombers, and fighter-bombers. They further noted that, based on the tardy but effective attacks on canals in France and Belgium, to make inland waterways a primary focus for transportation attacks. Finally, given the larger German transportation network, CSTC planners realized that they would have to limit the geographical area of attack to ensure bombing brought heavy and steady pressure to bear on German transportation assets.

The plan proposed to bound the geographic area by concentrating attacks in the north-south corridor between the Rhine River and longitude 10 East (roughly the line Hamburg-Hanover-Wurzburg-Ulm). In addition, it divided this area into zones and focused on the most important targets in each, which were to be struck as often as required to keep them out of action or nearly so. The objectives were to canalize traffic in each zone to make trains as vulnerable as possible and to destroy as many locomotive repair facilities as possible. The five zones included the northeast approaches to the

²⁵ AIR 20/4819, CSTC Working Committee (Communications), "Attack of German Transportation System," 7 November 1944, 1-2.

²⁶ Ibid., 2.

Ruhr, the Frankfurt-Mannheim zone, the Cologne-Coblenz zone, the Kassel zone, and the Karlsruhe-Stuttgart zone. East of the main corridor, attacks were to be made only against rail centers where the payoff was substantial. For instance, bombers attacked Munich's electrified railroad system to draw steam locomotives there once that system became inoperative. Fighters returning from escort missions were to conduct low-level attacks on moving trains, signal boxes, and switching apparatus to create additional friction.²⁷

The attack on inland waterways, proceeding concurrently with rail attacks, was designed to make long-distance haulage difficult by isolating component regions. The consequent diversion of goods to an already-damaged rail network would overload it. Both bombing raids and aerial mining were to accomplish this objective. Raids would breach key portions of the Dortmund-Ems-Mittelland canal system, sever the connection between the Mittelland Canal and the Elbe River, and destroy the Minden aqueduct to cut off the Mittelland Canal from the Weser River. River mining priorities included various points on the Rhine and Elbe Rivers.²⁸

The CSTC plan was for the most part both appropriate and effective. It was predicated on the fact that oil attacks would continue to have top priority, which proved reasonable given the central role of fuel shortages in the tactical, operational, and military-strategic catastrophes that befell German armies and air forces in the field after July 1944. The only unfortunate result of this prioritization was a habit among CSTC transportation attacks than they did with the oil industry. Indeed, the CSTC, ACIU, and

²⁷ Ibid., 2-3. Four additional zones were added later, as we will note later in this chapter.

²⁸ Ibid., 4-5.

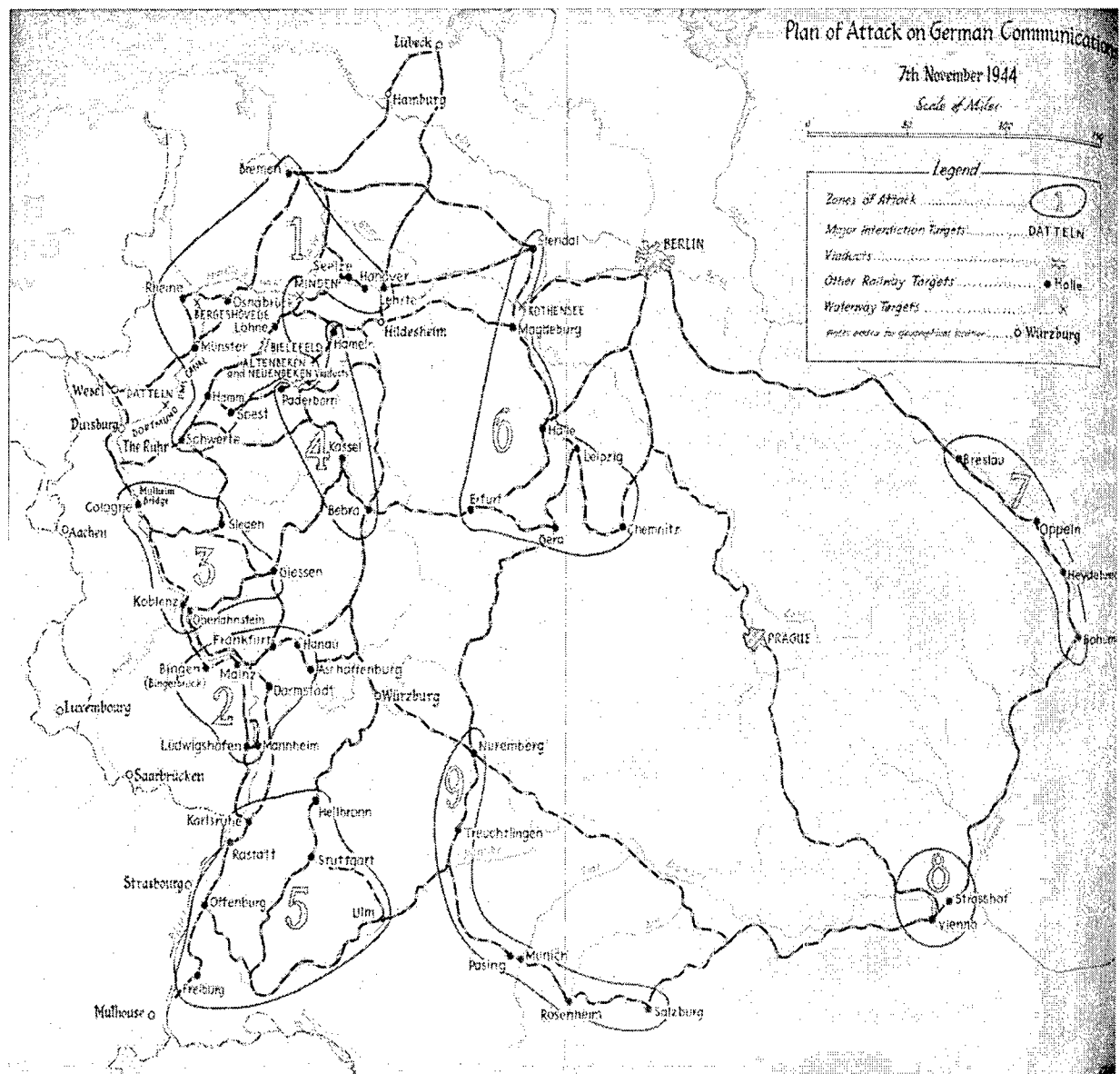


Figure 11.1: Transportation Plan Zones of Attack

Source: Sir Charles Webster and Noble Frankland, *The Strategic Air Offensive against Germany, 1939-1945, Volume III, Victory* (London: Her Majesty's Stationery Office, 1961), Map 9, 247.

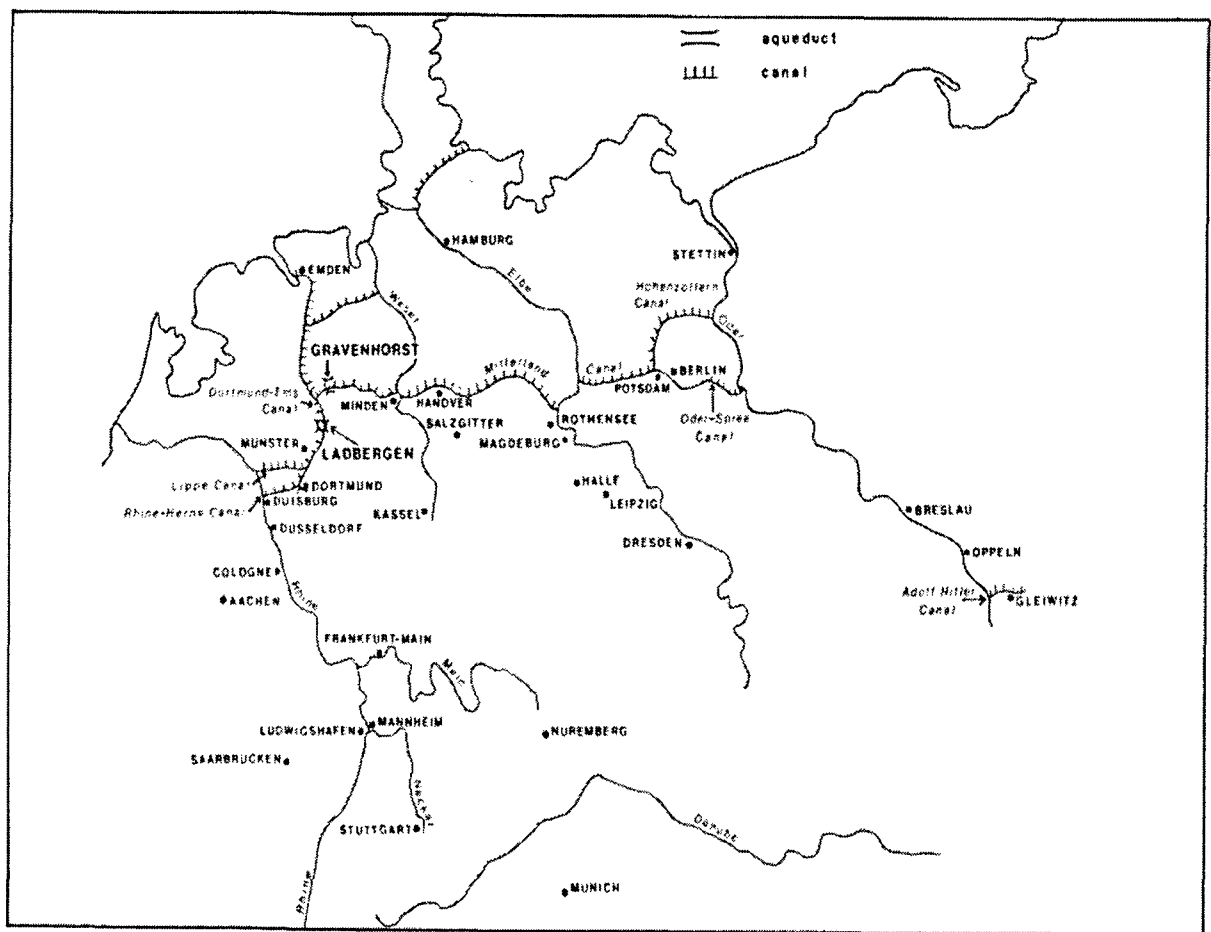


Figure 11.2: German Inland Waterways

Source: Alfred C. Mierzejewski, *The Collapse of the German War Economy, 1944-1945: Allied Air Power and the German National Railway* (Chapel Hill, NC: The University of North Carolina Press, 1988), Map 3.4, 57.

members of slighting the transportation offensive whenever they felt it threatened the oil campaign. In addition, they proved less capable of determining the effects of other targeting and air intelligence organizations failed fully to appreciate the devastating effects of raids on German marshalling yards until February 1945.²⁹

These priorities were based on a number of insights, gleaned from intelligence sources, indicating that Germany's transportation networks had reached a state of crisis. A CSTC report produced in November referenced an address by the Reich Transport Minister to *Reichsbahn* directors on 18 October, in which he declared that if the railways were stopped it would mean the end of the Greater Reich. He emphasized that "The point seems to have been reached...when the extent of the present operating difficulties

²⁹ See Mierzejewski, *The Collapse of the German War Economy*, 162-172. Mierzejewski's argument that the CSTC really warmed up to increased transportation attacks after the Russians captured the huge brown-coal mines in Upper Silesia during their January-February 1945 winter offensive is a sound one. They did seem to grasp, finally, that the capture of those coal mines made the Reich's remaining coal supplies, in the Ruhr, vital to Germany's war effort. Clearly, they should have recommended several months earlier that heavy bombers go after all the transportation nodes supporting the movement of coal in both the Ruhr and Upper Silesia. This was undoubtedly the CSTC's greatest single failure, as Mierzejewski argues, but it was more than counterbalanced by the success of the oil offensive. Once again, Mierzejewski focused exclusively on the transportation offensive without any discussion of the decisive effects of the oil campaign. In fact, he made only three references to the oil offensive in his entire book, which added up collectively to less than a single page of text. On page 181, he made the error of stating that attacks on oil alone could not have undermined German industry and thus could not have ended the war. This statement is fundamentally and seriously flawed on two counts. First, it assumes that Allied air intelligence and operations officers went after oil to undermine German war production, which was not the case. They went after oil to starve German armies and air forces in the field of fuel, which the oil offensive did very effectively. Second, there is overwhelming evidence to indicate that catastrophic fuel shortages played the leading role in ending the war in Europe. They played a central role in the collapse German resistance in France, led directly to the abject failure of the Ardennes Offensive (which had the added effect of making it impossible for German heavy divisions in the East to replenish their depleted fuel stocks), and, as we shall see later in this chapter, facilitated the dramatic and rapid successes of the Russian winter offensive as well as the final Allied drives into Germany. If CSTC members, with the notable exception of the SHAEF G-2 representative, were slow to recognize the great importance of transportation attacks, and it appears that they were, they had long since recognized the decisive effects of oil attacks on German military operations and were not about to divert bombers from oil targets. Mierzejewski also missed the fact that the oil offensive was already largely complete and successful by February 1945, at which point there was almost no fuel for German vehicles and aircraft regardless of production figures. February 1945 was, not coincidentally, also the month in which the CSTC finally warmed to the idea of transportation attacks. This was, of course, also the period in which the Red Army captured the Silesian coal mines.

may eventually overwhelm the reserves of the *Reichsbahn*.”³⁰ The key factors in this situation, he said, were damage to and disorganization of rail centers by air attack; an increasingly acute shortage of coal and lubricants; the rapid dwindling of locomotive reserves; reassignment of skilled railroad workers to the army in the wake of dual operational cataclysms in the East and West; low morale among remaining workers; and the reduction of road and water transport by bombing raids, which placed an even greater strain on the railroads. The Germans were not yet having problems moving troops to the front since experiences in France had taught them to move slowly and at night.

However, the CSTC noted that a crisis was developing: 42 percent of locomotives were unserviceable; repair shops were not keeping up with the rate of damage to locomotives; and many locomotives were being scrapped for spare parts. Operating difficulties had also increased sharply as a result of attacks on other targets, including *Reichsbahn* Divisional Directorate headquarters and most of the railroad telecommunications systems. In fact, the CSTC said that

Damage to the telecommunication system is one of the most satisfactory and crippling by-products of rail centre attacks, and has recently been achieved at Frankfurt and Karlsruhe. These systems cannot be restored to service in under two weeks and meanwhile operation within the division and coordination with neighbouring divisions is severely limited and may for brief periods become completely paralyzed.³¹

The CSTC asserted, based on these insights and others provided by BDA reports and Ultra intercepts, that the key problems facing the *Reichsbahn* were major locomotive shortages and the related scarcity of repair facilities, and a severe shortage of skilled and

³⁰ AIR 20/4819, CSTC Working Committee (Communications), “The Present State of the German Railways,” November 1944, 1.

³¹ Ibid., 3.

loyal personnel (over half were now foreigners). Finally, the report noted the rapid deterioration of the *Reichsbahn* and the possibilities inherent in continued bombing:

These two basic difficulties have largely been aggravated by air attacks on all types of railway targets in Western Germany, but especially by attacks on rail centres and on locomotives and trains. The effects on the deteriorating German railway potential are already visible in drastic cuts in economic traffic and in the imposition of a virtual ban on passenger travel. The situation is not yet so grave as to interfere with the highest priority military traffic and especially the movement of troops...It is conceivable, however, that further aggravation of operating difficulties in Western Germany may eventually have a direct effect on the movement of troops and essential supplies on the German network itself.³²

As the full extent of the catastrophe befalling the German transportation system became gradually clearer, Spaatz sent Eaker a cable emphasizing that the CSTC's transportation plan for the attack on German railroads and inland waterways, although focused on the area between the Rhine and the line of longitude 10-degrees east, also called for attacks against key marshalling yards in central and eastern Germany. These raids were designed to assist the Red Army's advance. "It so happens," Spaatz stated, "that the attack of transportation objectives in the two latter areas [central and eastern Germany] is particularly suitable for the support of military operations on the Eastern Front..."³³ As with the oil offensive, Spaatz was thinking of the larger benefits of the transportation campaign for the advance of Allied armies, especially on the vital Eastern Front. Spaatz's cable was in essence a show of support for the CSTC's decision to increase the number of rail targets to 65 and expand the number of zones to be attacked from five to nine. The new zones included key areas in central and eastern Germany.³⁴

³² Ibid., 4.

³³ MS16, S3, B5, F1, Cable, Spaatz to Eaker, 15 November 1944, 3.

³⁴ MS16, S3, B4, F3, "CSTC Communications targets priority signal No. 2," 17 November 1944.

The following week, Tedder, using his authority as the Deputy Supreme Commander and as Chairman of the Allied Air Commanders' Conferences held at the Air Ministry, directed that the Allies' Tactical Air Forces (TAF) aircraft conduct complementary attacks on fuel depots and dumps, benzol plants, and concentrations of tank cars in storage depots, marshalling yards, and railheads, as well as those underway. When attacks on these oil targets were not feasible, both strategic bombers and TAF assets were to attack transportation targets. These raids, he emphasized, were highly complementary to oil attacks and, based on recent experiences in France and Belgium, would go far towards disorganizing and slowing German troop and supply movements. The objective, he said, was the progressive disorganization of railroad and barge traffic. Tedder concluded with one of his inevitably well reasoned statements:

By carefully coordinating the operations of the Tactical Forces with those of the Strategic Forces, the attack on German communications can be so developed as to make a decisive contribution towards the success of the land campaign and the early defeat of Germany.³⁵

This directive indicated that Tedder did everything he could within the strictures of Bottomley's and Spaatz's bombing directives, which made oil the top priority, to give transportation targets additional emphasis precisely to maximize the synergy between attacks on these target sets.

As these discussions about the efficacy of transportation attacks continued, the CSTC Working Committee (Communications) developed a systematic means for determining how to prioritize their weekly target list. First, they relied on reconnaissance and strike photos, bomb plots, and ACIU interpretation reports. Then, based on the importance of

³⁵ AIR 2/8011, Tedder, "Attack of Oil and Communications Targets by the Tactical Air Forces," 23 November 1944, 1-2. Note that Tedder's focus continued to be on supporting the land campaign.

each rail center *in its current state of repair and capacity to move goods*, CSTC members employed the following truisms to prioritize targets: that the measure of dislocation arising out of an attack on a particular marshalling yard depended as a rule on the degree of damage caused to all of its component parts; that the time required for repairing a marshalling yard increased progressively in relation to the overall density of the attack; and that further attacks on partially damaged rail centers were not wasted since they would damage more facilities and hinder repair work. Weight of attack on the target mattered and should be directly proportional to the target's importance. With these sources in hand and these truisms in mind, the CSTC then contacted railroad experts at the ACIU, SHAEF, AI3(e), the RRS, and EOU to get their views on the efficacy of individual attacks and the need for new attack priorities. Once CSTC members had agreed on changes of priority, they phoned them to B.Ops.1 (Bomber Operations) at the Air Ministry and USSTAF for promulgation to Bomber Command and 8th as well as 15th and 9th Air Forces. The CSTC then sent out its amended target list by cable.³⁶

Despite the severe damage done to transportation targets in the aggregate, the picture was not entirely rosy. An ACIU F Section report on more than 20 recent attacks on rail centers showed that in no case was throughput entirely impaired. Only four attacks had resulted in any interruption in service, and no more than 50 percent in any one case.³⁷ Sobered by this reminder that even good bombing using the technologies and techniques at hand was often not very accurate, the CSTC asked the photointerpreters of F Section to

³⁶ AIR 20/4819, CSTC, "Procedure for Day to Day Amendment of Priorities," March 1945, 1-2.

³⁷ AIR 2/8011, Minutes, CSTC 7th Meeting held on 29 November 1944, 3 December 1944, 3. ACIU F Section issued reports on traffic concentrations and movement; determined the location, layout, and vulnerability of all communications targets including marshalling yards, bridges, and canals; and assessed the interruption of traffic following attacks and the speed with which damaged facilities were repaired.

publish this study every week in order to assist with determining target priorities. Central to this problem of poor accuracy was the fall and winter weather and senior airmen's determination to continue attacks even when the weather refused to cooperate. In a memo to Doolittle, Spaatz stated that 8th Air Force heavies were to attack transportation targets under visual conditions if possible, but to attack cloud-covered targets using H2X if no other option existed. He also said that bombers heading to oil targets should switch to alternate targets—all of them transportation facilities—if weather reconnaissance reported their primary targets to be cloud-covered. In this case, the best H2X operators from each wing would lead the attack on these targets, "For it is our experience that even two or three wings' bombs can put these targets out of commission."³⁸

Equally troubling was the fixation on transportation attacks for tactical and operational purposes rather than for military-strategic ones, including the destruction of Germany's war economy. Yet the CSTC had begun to shift its focus to military-strategic targets by December. The SHAEF G-2 representative, Group Captain Morley, observed that it would be possible "to disorganize the German railways to such an extent as to cause economic, as opposed to military, paralysis in Germany."³⁹ Indeed, the CSTC's meeting minutes from 13 December said:

the request of S.H.A.E.F. to attack targets which had some relation to military movements at any given time might not conflict with the *primary aim* of causing the maximum degree of economic disorganization. Mr. Lawrence said that he agreed that S.H.A.E.F.'s request for the attack of particular targets would not conflict with the intention of causing economic disorganization...⁴⁰

³⁸ Spaatz Box 84, Memo, Spaatz to Doolittle, 11 December 1944.

³⁹ AIR 2/8011, Minutes, CSTC 9th Meeting held on 13 December 1944, 15 December 1944, 5.

⁴⁰ Ibid., 5-6. Emphasis added.

This exchange underscored the fact that the CSTC's objective in recommending transportation targets for attack was no longer purely operational in nature but was becoming truly strategic in its focus on disorganizing the German war economy. And once the Allies had checked the German advance during the Ardennes Offensive, CSTC target lists again began to reflect a primary focus on the disruption of German coal shipments and, by extension, war industries.⁴¹

In the short term, however, the Ardennes Offensive forced a massive shift of bomber assets to attacks on marshalling yards and bridges behind the front. And once again, Ultra intercepts made clear their significant effects. Major raids on Cologne on 21 and 22 December caused severe damage to the permanent ways and many key facilities at the Cologne Ehrenfeld and Cologne Nippes rail centers, stopping all movement for two days.⁴² The next week, Army Group B complained that the destruction of railway lines, marshalling yards, and road junctions in the Eifel was making the supply situation tenuous.⁴³ Another 20 intercepts during the next week emphasized the severe damage caused by bombers flying interdiction missions against rail targets.⁴⁴ On 10 January, a message to Army Group G said rail centers at Cologne, Saarbrücken, and Karlsruhe were severely damaged and the traffic situation very strained. Repair shops were out of action, many locomotives unserviceable, and traffic severely backed up.⁴⁵

⁴¹ AIR 2/8011, Minutes, CSTC 10th Meeting held on 22 December 1944, 26 December 1944, 8.

⁴² AIR 40/2658, A.I.3.(e), "Extracts from CI/MSS giving the effects of air attacks on German Communications, as from 1.10.44," 28 February 1945, 4, intercepts T.412/84 and T.413/17 of 21 and 22 December 1944.

⁴³ Ibid., intercept T.416/58 of 28 December 1944.

⁴⁴ Ibid., 4-5.

⁴⁵ Ibid., 6, intercept T.433/76 of 10 January 1945.

An increasing number of POW interrogation reports joined Ultra intercepts as vital BDA tools in late 1944. One such report concerned a German noncommissioned officer who had worked for the *Reichsbahn* from February 1941 to September 1944. He confirmed BDA reports that locomotives were in very short supply, their maintenance inadequate due to the scarcity of functioning repair shops, and that air attacks were making the situation worse all the time. He also corroborated a number of specific damage assessments to various marshalling yards.⁴⁶

Despite the serious damage being done to railroads and canals, there was still nothing like the targeting focus in evidence for the oil offensive. At a CSTC meeting in late December, Bufton complained that the transportation targeting process was in disarray and that serious differences of opinion about the proper focus of such attacks existed in the CSTC. He said it was time to determine which kinds of attacks (on the economy, on military movement, or on "close support" of the ground battle) made the most sense and to arrive at a common view.⁴⁷ Although this lack of focus was a serious problem, it was largely unavoidable, despite Bufton's efforts, due to the constant demands placed upon the heavy-bomber force to support Allied armies.

The problem was not yet resolved three weeks later, when, during a long discussion about the effects of transportation attacks, CSTC representatives argued about whether such attacks should focus on degrading the German army's logistics, undermining the German war economy, or both. Ironically, the weight of bombs dropped on transportation targets was six times that dropped on oil in December 1944, but the pay-

⁴⁶ RG243, E36, B106, CSDIC (UK), SIR 1395, "Report on Information Gained from PW CS/1132, *Unteroffizier* Müller, 10th Company, Grenadier Regiment 732, Captured near Dussen, 30 Dec 44, Notes on Railway Operation in South Germany," 29 December 1944, 1-2.

⁴⁷ AIR 2/8011, Minutes, CSTC 11th Meeting held on 27 December 1944, 30 December 1944, 4-5.

off not as great. Still, these attacks caused severe damage to railroads and canals, disrupting the movement of coal. The Dortmund-Ems Canal, a vital conduit for the distribution of coal, had been out of action continuously for four months.⁴⁸

A week later, the JIC entered the fray, arguing that attacks should focus on support to the Red Army's advance.⁴⁹ Even the Air Minister, Sir Archibald Sinclair, got involved, sending a Minute to Churchill stating that the oil campaign was doing more for the war effort than attacks on rail centers.⁵⁰ Yet the next day he changed his mind, arguing that:

Available effort should be directed against Berlin, Dresden, Chemnitz and Leipzig or against other cities where severe bombing would not only destroy communications vital to the evacuation from the East but would also hamper the movement of troops from the West. The use of the night bomber forces offers the best prospects of destroying these industrial areas without detracting from our offensive on oil targets, which is now in a critical phase.⁵¹

He had changed his tune, literally overnight, because the Soviets requested raids on rail centers in and around these cities to increase the effectiveness of their winter offensive. This attack, which had already run most German divisions out of the little gasoline they had when it began, was now churning through Upper Silesia and towards the Oder River.

11.3 Convergence: Synergy between the Oil and Transportation Offensives

As Allied senior airmen debated the best targets for bombers engaged in transportation attacks, oil attacks continued to destroy what little was left of the German oil industry. As we saw in the previous chapter, Spaatz, Bottomley, Bufton, and Maxwell all recognized that the oil offensive would pay its greatest dividends in the East if and

⁴⁸ AIR 2/8011, Minutes, CSTC 14th Meeting held on 17 January 1945, 20 January 1945, 2, 10.

⁴⁹ AIR 8/1745, Air Staff Note, "Strategic Bombing in Relation to the Present Russian Offensive," 26 January 1945 (note by Air Staff with reference to J.I.C. (45) 31 (O) Final dated 25th Jan. 1945), 1-5.

⁵⁰ AIR 8/1745, Minute, Sinclair to Churchill, 26 January 1945.

⁵¹ AIR 8/1745, Minute, Sinclair to Churchill, 27 January 1945.

when the Soviets launched a winter offensive, something the Germans did not expect them to do. The Germans miscalculated, with disastrous results. The Red Army's two drives into Upper Silesia and towards the Oder River, which began on 12 January 1945, caught the Germans completely by surprise and, even more important, almost entirely out of gasoline. To make matters worse for the Germans, they had a dysfunctional supply system that had caused them severe operational problems from the start of the Soviet summer offensive in June 1944 and continued to do so during this surprise winter assault. It was the combination of severe fuel shortages brought on by the oil offensive; superb Red Army offensive operations; transportation attacks that hampered the movement of heavy weapons, fuel, and ammunition to the front; and this ineffective supply system that came together in early 1945 to seal the fate of the Third Reich's armies in the East.⁵²

The fundamental problem with the German supply system—one that made it exceptionally vulnerable to this combination of factors—was a clear bifurcation of operational and supply responsibilities in the German army. This posed serious operational risks, particularly if and when the ability to keep supplies moving forward was hampered by a combination of Allied bombing or ground advance, and it was particularly dangerous on the huge Eastern Front. In that vital theater of operations, poor placement of fuel and ammunition depots combined with decreasing deliveries of these vital commodities and deep Soviet penetrations of the front line to produce a series of operational cataclysms that destroyed the cream of the German army in the East,

⁵² *Obergruppenführer* Sepp Dietrich, who had extensive command and combat experience on both the Eastern and Western Fronts, simply said of the Red Army of 1944-45: "They exploited the poor and inefficient German supply system..." See RG243, E36, B185, 7th Army Interrogation Center, "Interrogation of SS-OGRUF and GENOBST Josef 'Sepp' Dietrich, Commander, 1SS Panzer Corps, 1944," 11 June 1945, 10.

shortening the war and Allied casualty lists. The Wehrmacht's—and Hitler's—cavalier attitude towards logistics is reflected in the fact that the Führer and his staff thought it unnecessary to have a supply expert present at their daily conferences. Consequently, logistical difficulties were not given sufficient consideration in operational decisions. Ironically, oil and transportation attacks drove a centralization of supply functions at OKW. The result was a shift from a supply system in which nobody at the Führer's conferences paid attention to the details of distributing supplies or the structure of the depot system, to one in which rigid centralization produced inflexibility. To compound matters, there was no head of supply for the military; each service had its own *Quartiermeister*. This led to duplication of effort and a waste of resources.⁵³

Another serious problem had to do with the fact that supply channels ran directly from the *General Quartiermeister* of the army directly to the chief supply officers of the various field armies. Army groups were *not* part of official supply channels until December 1944, nor were army corps headquarters. In fact, there was no centralized control of supply at the three fighting fronts. Field armies were instead responsible for carrying and distributing supplies. They did so, in theory, through Army Supply Distribution Groups and their motor transport regiments and battalions, which were supposed to carry supplies to combat divisions at the front. In reality, these units had too few trucks, so combat divisions were forced to use their own trucks to haul supplies. To make matters worse, combat divisions heading to the front were only allowed to have as many supplies as they could carry away in their own transport. This meant they had no

⁵³ RG243, E36, B187, CSDIC (UK), "A Survey of the Supply System of the German Army 1939-45," 25 August 1945, 4-7. This outstanding document was based on interrogations of eight senior German supply officers (from *Oberstleutnant* to *Generalleutnant*), whose names, ranks, and duties are on pages 2-3.

significant supply dumps of their own. Finally, and the thing that made German logistics particularly vulnerable to any systemic shortage of fuel, was the policy on the Eastern Front of placing large fuel and ammunition depots at the field army level, about 60 miles behind the front. Combat divisions, which did not receive adequate supplies from Army Supply Distribution Groups, often had to send their own trucks to obtain supplies. This placed the Germans in a situation like the one in Normandy, where they had to send each division's trucks on supply runs rather than using them to shift troops to key areas.⁵⁴

The irony here is that German armies in the East, unlike their counterparts in the West, *did not have to do business in this fashion*. The threat from air attack was much lower, and the Germans therefore had the ability to place large supply dumps—or alternatively a large number of smaller ones—closer to the front, where truck convoys from the combat divisions could load up and be back at the front within hours rather than days. Nonetheless, the placement of large depots 60 or more miles behind the front line was simply the way things were done, and nobody with sufficient authority ever did anything to change the process.

There were three great dangers in this system. The first was the possibility that divisions would be forced to fight too far from their field-army's supply depot. The

⁵⁴ Ibid., 17-19; Geoffrey P. Megargee, *Inside Hitler's High Command* (Lawrence, KS: University Press of Kansas, 2000), 122. In a postwar interrogation, Albert Speer said "Naturally we had a supply organization of the Army maintaining large ammunition dumps behind the front in order to satisfy the needs of the front. In fact these dumps were very large, and out of all proportion to what was available at the front itself. It was just this fact which caused the heavy losses in ammunition during retreats, because then these dumps were lost." The same thing happened with army-level fuel dumps (*Marschtanklagers*), which further emphasizes the interaction of Allied bombing with poor German logistical practice, in which the former caused an absolute shortage of fuel and the latter often made what little there was largely inaccessible to German units at the front. See AIR 20/8780, Technical Control Commission for Germany (BZ), Field Information Agency, Report No. 54, "Problems of Supply in the Armed Forces," 11 October 1945, 5, based on a 13 July 1945 interrogation of Albert Speer.

second was that they might lack the trucks and perhaps the gasoline (another rich irony!) to retrieve supplies. The third and most dangerous was the possibility that Soviet armored spearheads would penetrate the front to a depth sufficient to cut off divisions from their army-level supply depots. If any of these situations were to develop, serious fuel and ammunition shortages would result. Once a division's three to five consumption units of fuel were used up or captured, re-supply at the division and *Kampfgruppe* level became extremely difficult or impossible. The huge expanses in the East also meant that trucks were in most cases the only means for getting supplies from army-level depots to the front. If these depots were overrun and the fuel pipeline disrupted, combat units would have to rely on the fuel supplies they already had or retreat sufficient distances to receive fuel supplies at the railheads. This Hitler in most cases refused to countenance, insisting that army units hold their ground and fight as far forward as possible.⁵⁵

The result of these conditions in the East after 1943—German logistical weaknesses, Russian expertise in rapid and deep penetrations along narrow frontages, Hitler's hold-fast orders, an increasingly severe fuel shortage brought on by Allied bombing, and the mounting chaos within the already-weak German logistical system caused by heavy-bomber raids on marshalling yards—robbed the Germans of their greatest operational strength: the maneuver and firepower expertise of their armored formations. Once the oil offensive got into high gear and fuel stocks at the division and army level were either used up or overrun, there was often no fuel available where and when surviving German combat units needed it. This was due to both an absolute shortage of fuel and the

⁵⁵ Earl Ziemke noted the disastrous impact of Hitler's stand-fast orders during the Russian counterattack at Stalingrad and in virtually every major action afterwards. See *Stalingrad to Berlin*, 193.

inability of the German logistical system to deliver it quickly to the railheads and from there to the fighting formations in an effective and timely fashion. Albert Speer confirmed that "Fuel was only obtainable by chance and not at the place where it would be needed."⁵⁶ In the summer and fall of 1944, field armies and divisions were left to their own devices as they sought to obtain adequate fuel. In most cases they failed to do so. It was here, in combination with the factors mentioned previously, that the Allied oil offensive had its greatest operational impact and made its greatest contribution to the Allied victory over Germany.

Increasingly severe fuel shortages made German counterattacks difficult or impossible. Even after the front stabilized as the Russians experienced logistical problems of their own in the late fall of 1944, the Germans were unable to rebuild their fuel stocks as they had done in previous lulls in the fighting because Allied bombing had destroyed too much fuel-production capacity. In addition, Hitler's decision to launch the Ardennes Offensive forced the Germans to allocate *half* of their gasoline production for November and December 1944 to that dubious venture, which meant even less fuel went to replenish army-level fuel dumps in the East.⁵⁷ Efforts to counter the Red Army's advance were stymied by fuel shortages, which manifested themselves in the much-reduced fuel increments available to German heavy divisions by 1945.

Until the fall of 1944, the normal issue of fuel to an armored division was five consumption units (enough to move it 310 miles over paved roads in good weather). In

⁵⁶ RG243, E2, Box 59, USSBS, Military Analysis Division, *The Impact of Allied Air Effort on German Logistics*, 2nd ed., January 1947, 32. Based on 3 November 1945 interrogation.

⁵⁷ Ziemke is as yet the only author who has used surviving German operational records, now located at the National Archives, to assess the role of fuel and ammunition shortages in the operational disasters on the Eastern Front from June 1944 to the end of the war. As he notes, these shortages became pervasive in the late summer of 1944 and catastrophic by January 1945. See *Stalingrad to Berlin*, Chapters XIX-XX.

practice, however, five fuel consumption units could move a division at most 200 miles in good weather over open terrain and on back roads. Once the weather and road conditions worsened, this quota might move a division as little as 125 miles.⁵⁸ Fuel allotments were made to fighting units monthly until late summer 1944, at which point bombing-induced shortages led to the issuance of fuel quotas every 10 days, then every five. This meant army units had to live from hand to mouth after summer 1944 due to these very limited and unreliable allotments. Given the tempo of the oil offensive, fuel allocations were reduced in fall 1944 from five consumption units to two or three for heavy divisions. The magnitude of the fuel shortage then became painfully evident to German troops, especially once the Russians launched their winter offensive.⁵⁹ Also, tanks used three times as much fuel in muddy conditions as in dry conditions, and the winter and early spring of 1945 in Eastern Europe were particularly muddy.

The upshot of all these logistical woes was a massive fuel shortage that resulted in the immobilization of about 1,200 German tanks and assault guns at the Baranow bridgehead—no less than 65 percent of the 1,850 they had on the entire Eastern Front—within the first few days of the Russian offensive, an operational cataclysm from which the Germans never recovered.⁶⁰ Albert Speer commented on the enormity of this disaster during a postwar interrogation:

We had utilized here approximately 1200 tanks for the defense and here it was for the first time that the troops had only one or two sets of supplies for fuel [fuel increments] so that the tanks were practically unable to move when the Russian attack started. To the best of my knowledge tanks were not utilized again [in large quantities] in battle...In this sense one can say that your attacks in the chemical

⁵⁸ See RG243, E32, B2, "Interrogation of Colonel Otto Eckstein," 10-11.

⁵⁹ RG243, E36, B187, CSDIC(UK), "A Survey of the Supply System of the German Army 1939-45," 25 August 1945, 43-44.

⁶⁰ See Earl Ziemke, *Stalingrad to Berlin*, 417.

sector [synthetic oil plants] have considerably influenced the defense against this offensive. We could notice on the basis of all other information which we got...that this offensive could have been stopped...had it not been for the lack of fuel. The quick breakthrough came only because of insufficient supplies of fuel. The quick loss of Upper Silesia, which was practically the last push to break the neck of the entire armament industry was therefore caused through the attacks on the hydrogenation plants.⁶¹

The shortage of fuel Speer referred to was a product not only of the oil offensive, but also of transportation attacks that made delivery of fuel and ammunition unreliable or impossible. German senior leaders were unanimous in emphasizing the disastrous impact of air attacks on transportation networks and, by extension, on the German war effort. In this case, the German habit of shipping fuel and blending agents such as benzol and alcohol to major depots for bulk-breaking, blending, and transport to the fighting fronts made fuel and the trains transporting it even more vulnerable targets. Blending at these depots occurred at great distances from crude oil refineries, synthetic oil plants, benzol plants, and other fuel producers, which meant transportation attacks played havoc with the Germans' ability to move fuel from origin to blending depots and then on to the fighting fronts. Equally problematic was the large proportion of fuel that had to be kept in the "pipeline" that stretched from oil plants and refineries to troops at the front. The fuel pipeline included all fuel in circulation and was the minimum needed to keep combat units supplied. About 10 percent of all fuel was in transport at any given time, which made fuel supplies very susceptible to transportation attacks.⁶² As a USSBS study noted:

The bombing of oil targets was concomitant with the attacks on transport in bringing about a paralysis of the German logistics system. This blocking of logistic circulation, together with the draining through battle wastage of the supplies

⁶¹ RG243, E31, B1, "USSBS Interview No. 11, Subject: Reichsminister Albert Speer," 31 May 1945, Minutes of a 19 May 1945 interrogation, 5.

⁶² RG243, E2, Box 59, USSBS Military Analysis Division, *The Impact of Allied Air Effort on German Logistics*, 2nd ed., January 1947, 8.

remaining in the system, was the immediate cause of the collapse of the German armies at the time it occurred.⁶³

This passage referred to the collapse of German armies at the end of the war, but it is important to recognize that similar collapses occurred in Normandy, on the retreat from France, during the Red Army's summer offensive, late in the Ardennes Offensive, and with particular force once the Russian winter offensive began in January 1945.

Viewed in this light, the synergy between oil and transportation attacks clearly shortened the war and Allied casualty lists. The crucial thing to bear in mind here is that Allied air intelligence organizations and senior airmen recognized the importance of reducing German fuel supplies on every fighting front, and especially in the East. Spaatz, Bottomley, Portal, Tedder, and the chairmen of the CSTC understood this and did their utmost to make a significant impact on military operations on the Eastern Front, a feat they carried through with outstanding results.

The abject failure to provide effective logistics for German armies was perhaps best summed up when *General der Artillerie* Franz Halder observed that "According to our opinion, the material has to serve the spiritual. Accordingly, our quartermaster service may never hamper the operational concept."⁶⁴ In perhaps the greatest irony of all, the OKW created a situation in which the quartermaster service did exactly what they did *not* want it to do: it hampered the operational concept severely, though for reasons none of them could have foreseen.

As the prospects for a successful completion of the oil offensive brightened in January 1945, Bufton told Portal that Harris was again dragging his feet. Bufton believed

⁶³ Ibid., 8-9.

⁶⁴ Megargee, *Inside Hitler's High Command*, 122.

Harris had no faith in the oil plan and was not supporting it. He and Maxwell had asked Harris repeatedly to attack Leuna, Pölit, and Brück, but he refused, claiming that night precision raids were costing Bomber Command 5-10 percent losses. Bufton noted that the actual loss rate was 1.04 percent. He also noted Harris's "strong antipathy to MEW" and all other intelligence agencies. In fact, Harris had criticized oil attacks again in a recent memo and advocated a return to area attacks! Bufton reminded Portal that the purpose of the oil offensive was "progressively to restrict the mobility of [the enemy's] Armies in the field and the operations of his Air Forces. This it is most successfully doing."⁶⁵ Even more important was his reminder that

The attack of oil and communications are complementary. If we relax in our attacks on oil, communication attacks will immediately have less significance. The use of substitute methods of transport cannot, of course, compensate for lack of motor transport. Commercial, Industrial and Military efficiency must fall when bullock wagons replace motor lorries.⁶⁶

Portal spoke with Harris again, and the CSTC released a target list that closed with a pointed exhortation "to concentrate all resources on a final drive to cripple the enemy's oil production."⁶⁷

Perhaps coincidentally—but probably not—Bottomley and Spaatz issued their third and final bombing directive just over a week after this run-in with Harris. The directive again placed emphasis on the destruction of oil plants engaged in gasoline production as well as depots known to be storing large quantities of it.⁶⁸ This directive coincided with two weeks of good weather, which heralded the doom of what remained of Germany's oil industry. Pölit was raided the night of 13-14 January and Leuna the following night. In

⁶⁵ AIR 40/2658, Memo, Bufton to Portal, commenting on Harris's memo, 3 January 1945, 6.

⁶⁶ Ibid.

⁶⁷ MS16, S3, B5, F4, CSTC oil targets priority signal 1/45, 4 January 1945, 3.

⁶⁸ Spaatz Box 20, "Directive No. 3 for the Strategic Air Forces in Europe," 12 January 1945, 1-2.

the attack on Pölitz, 218 Lancaster heavy bombers dropped 813 tons of munitions, while the attack on Leuna, carried out by 573 Lancasters, delivered 2,190 tons. The British, based on night strike photography and post-strike reconnaissance, declared that Pölitz “had been reduced to a shambles” and Leuna just as severely damaged. Both of these were night precision raids.⁶⁹

Albert Speer said the Pölitz and Leuna raids were some of the “most damaging” made on oil plants. His 19 January memo to Hitler conveyed a growing sense of despair:

My Führer, Since 13 January 1945 a new series of heavy attacks on the oil industry has been introduced, which has already led to prolonged shutdown of the great hydrogenation plants of Pölitz, Leuna, Brüx, Blechhammer, and Zeitz, in addition to the complete shutdown during the last quarter of 1944 of all Western plants, especially Scholven, Wesseling, [Bottrop]-Welheim, and Gelsenberg [Gelsenkirchen]. The repair of the plants after each attack has become more difficult owing to the use or destruction of reserves of machines and equipment; in addition, repairs take a longer time. It must also be stated that the now frequent night attacks are more effective than the day raids as heavier bombs are being used and an extraordinary accuracy achieved; therefore, even if the repair and production during the first quarter of 1945 were to proceed undisturbed, the planned production, which during the final quarter of last year seemed possible, can no longer be achieved. Heil Hitler! [Signed] Albert Speer, Reichsminister for Armaments Production.⁷⁰

Just as significant was proof that work crews were cannibalizing the wrecked oil plant at Wesseling for parts. Also, ACIU photointerpreters noted that both Gelsenkirchen-Nordstern and Ludwigshafen were abandoned.”⁷¹ Even more important,

⁶⁹ MS16, S3, B5, F4, CSTC, “The oil offensive. Progress report number 6. Week ending January 14,” 17 January 1945; AIR 2/8011, Minutes, CSTC 14th Meeting held on 17 January 1945, 20 January 1945, 1; Middlebrook and Everitt, *The Bomber Command War Diaries*, 652.

⁷⁰ AIR 20/8780, Control Commission for Germany (BZ), Field Information Agency, Report No. 62, Interrogation of Albert Speer on “The Effects of Aerial Warfare and Allied Successes on German War Production” (interviewed on 6 September 1945), 8 November 1945, 25. Also in USSBS Oil Division, *Oil Division Final Report*, 2nd Ed., January 1947.

⁷¹ MS16, S5, B8, F7, “Combined Strategic Targets Committee, Working Committee (Oil Production and P.O.L. Depots), Weekly Bulletin No. 1945-3,” 16 January 1945, 3.

as the next CSTC report stated, was the resumption of Soviet offensive action. The renewed Russian advance, it said,

is of great significance to the oil offensive. In the first place it will inevitably increase the enemy's minimum requirements of POL by a substantial percentage at a time when his production has suffered fresh blows and may make it impossible for the enemy again to build up reserves from his current production for offensive purposes, as in the autumn. In the second place it promises to deprive the enemy of important sources of production. The remaining Polish refineries and the Hungarian oilfields are imminently threatened and, having regard to the speed of the advance, the position of the Silesian Synthetic Plants is beginning to look precarious. In this situation, the immobilization of the remaining large synthetic plants takes on a greater significance than ever before and demands the highest priority. At the same time the target value, on a lower priority, of Benzol Plants has been enhanced.⁷²

During the following week, reconnaissance cover showed only six Bergius plants still in operation (Brüx, Pölitz, Leuna, Gelsenkirchen-Nordstern, Scholven, and Blechhammer South). The output of the entire synthetic oil industry was now only 110,000 tons per month, of which 65,000 tons was gasoline and aviation fuel. In addition, Blechhammer North and South were threatened with capture by the Red Army. Between the continuing oil attacks and the Red Army's advance, German oil production was being hounded to the point of complete failure.⁷³

Yet another period of good weather the following week led to more devastating attacks by Bomber Command heavies, this time against Brüx and Zeitz, the former with 231 Lancasters dropping 856 tons of bombs, and the latter with 328 Lancasters dropping 1,304 tons. Both caused serious damage, with Speer again mentioning that the attack on Brüx was a particularly severe setback to oil production. Once again, both raids were

⁷² MS16, S3, B5, F4, CSTC Target List, CSTC oil targets priority signal 3/45, 20 January 1945, 3.

⁷³ MS16, S5, B8, F7, "Combined Strategic Targets Committee, Working Committee (Oil Production and P.O.L. Depots), Weekly Bulletin No. 1945-4," 23 January 1945, 1-4.

night precision attacks.⁷⁴ Neither plant would produce any more oil or fuel before the end of the war. Spaatz was so impressed with these attacks that he asked the Air Ministry for details on the tactics employed during the raid on Br  x. The Air Ministry reply noted that the 231 Lancasters had dropped 189 of the huge 4,000-lb. hard-case bombs, 1,305 of their 500-lb. medium-case munitions, 624 of the 500-lb. general-purpose bomb, and 392 of their ANM 64 incendiaries. A total of 202 of the 500-lb. bombs had delay fuses of between six and 144 hours. Pathfinder Force Lancasters navigating with H2S Mark III radar sets dropped green target indicators followed by flares to illuminate the target area. Low-flying Pathfinder Force Mosquitoes then acquired the target visually and marked it with red 1,000-lb. target-marking flares that deployed at altitudes between 1,400 and 400 feet. To do this, they flew *under* the 10/10ths cloud cover obscuring the target. The Master Bomber in the lead aircraft controlled the attack from start to finish, ordering crews to drop their bombs on the glow of the target indicators, which was visible through the clouds covering the target. The Lancaster crews bombed *individually* from altitudes between 12,000 and 18,000 feet.⁷⁵ To say these tactics indicated a high degree of proficiency would be a dramatic understatement. This stunning feat of airmanship, repeated a number of times against the Germans' large Bergius plants between December 1944 and March 1945, indicated just how good Bomber Command's elite formations, and even the main-force units, had become by this time. We can only wonder how much more quickly the oil offensive would have produced decisive results had Bomber Command come in on it from the outset.

⁷⁴ MS16, S3, B5, F4, CSTC, "The oil offensive. Progress report number 7. Week ending January 21," 23 January 1945; Middlebrook and Everitt, *Bomber Command War Diaries*, 653.

⁷⁵ MS16, S3, B5, F4, Cable, Air Ministry to Spaatz, 29 January 1945.

It is important to note that there were key differences between the effects of RAF and USAAF raids. As we have seen, the former delivered larger payloads and bombs, including 4,000-lb. munitions whose blast effect caused severe damage to the vital above-ground pipelines that delivered steam pressure, coal sludge, oil, and fuel to the various parts of oil plants, and the buried electrical conduits and water pipes without which the plants could not function. The payloads alone indicate the potential disparity in effects: while RAF bombers in the Br  x and Leuna missions just discussed dropped 856 tons and 1,304 tons, respectively, the 8th Air Force raid on Harburg, which produced good but more modest results, delivered 187 tons. And this attack was the *largest* of the week's raids by USAAF heavies (the others delivered 150, 113, 106, 100, and 93 tons). Put simply, only Bomber Command could deliver crushing blows against the last operational oil plants, something about which Bufton, who had a close working relationship with Portal, reminded his chief constantly. Portal, in turn, did everything he could to keep Harris from drifting back into city bombing while there were still oil plants to destroy.

These spectacular Bomber Command attacks, and several impressive ones carried out by 8th and 15th Air Forces, reduced German gasoline production for January to 97,000 tons—18 percent of its pre-attack level, an all-time low.⁷⁶ In the meantime, the Russians overran the Bergius plants at Blechhammer North and South in early February.⁷⁷ During this period, the Allies also carried out heavy attacks on benzol plants, which were now producing the majority of German fuel. A measure of the overwhelming Allied air strength was a Bomber Command attack, by 286 Lancasters, against the Bruckhausen

⁷⁶ MS16, S3, B5, F4, Cable, Curtis (USSTAF Chief of Staff) to Spaatz, 24 January 1945.

⁷⁷ MS16, S5, B8, F7, "Combined Strategic Targets Committee, Working Committee (Oil Production and P.O.L. Depots), Weekly Bulletin No. 1945-5," 30 January 1945, 1.

benzol plant in Duisburg, which was obliterated by the 1,291 tons of bombs dropped on it—a huge figure given the nature of the target.⁷⁸

Clearly, the Allies were out to destroy the German POL industry utterly and quickly, and the results were becoming clearer by the day. In the West, supply returns for Fifth Panzer Army for 7-10 January showed a drop of 210 tons (41 percent) in fuel stocks because there were no new allocations at all the week of 7 January. That left armored units with 0.38 consumption units, enough to allow for a move of 24 miles on good roads in fair weather and perhaps 8 miles on muddy or snowy roads.⁷⁹ Two weeks later, the 9th Panzer Division made an urgent request for fuel. Only 5 tons of 11 allocated had arrived, and this had already been used towing tanks—themselves out of gas—from Weissenbach. On the same day, Army Group G reported that the offensive strength of its divisions had been undermined by a shortage of artillery ammunition and the abandonment of almost all self-propelled and towed artillery owing to a shortage of fuel.⁸⁰ A week later, Army Group B said the situation remained very strained due to the very slow arrival of three Panzer Grenadier divisions due to a lack of fuel.⁸¹ At the same time, the 116th Panzer and 15th Panzer Grenadier Divisions reported that they had enough fuel to travel 21 and 36 miles, respectively.⁸² A month later, the range of 116th Panzer was 10 miles.⁸³

⁷⁸ MS16, S3, B5, F4, CSTC, "The oil offensive, Progress report no.8 week ending Jan 28, 1945," 30 January 1945, 1; Middlebrook and Everitt, *The Bomber Command War Diaries*, 654.

⁷⁹ RG457, E9002, B12, "German Fuel Position: Estimate by G-2 SHAEF on 29 January," 31 January 1945, 1; AIR 40/2658, AI3(c)2, ULTRA (MSS) intercepts, Continuation of earlier list, intercepts for January and February 1945, 3 March 1945, 7 January intercept.

⁸⁰ Ibid., 25 January intercepts.

⁸¹ Ibid., 3 February intercept.

⁸² RG457, E9002, B12, "German Fuel Position on the Western Front Since the Opening of the Allied Offensive in February: Summary by G-2 SHAEF on 21 March," 27 March 1945, 2-3, 8 February intercept.

⁸³ Ibid., 4, 8 March intercept.

Things were even worse in the East given the mobile operations there as opposed to the still largely static operations in the West. In a clear reference to the Russian winter offensive, a SHAEF G-2 report said German fuel production had collapsed "at a moment when operational fuel requirements are higher than at any time in the last six months."⁸⁴ The same report noted that in the East, Ninth Army reported on 21 January that one of its Panzer corps would be unable to cover its flanks by mobile operations in the Lodz area because of lack of fuel. The fuel shortage had forced Panzer Corps *Grossdeutschland* and several other units to withdraw, rather than opposing the Russian advance, in an effort to keep their vehicles from running out of fuel.⁸⁵ A 14 February report from Army Group Vistula said the entire army group would be partially immobile for the day given recent increases in fuel consumption due to the positioning of several divisions opposite Russian areas of concentration. Fuel returns from the Second Army on the Eastern Front, and the First Parachute, Nineteenth, and Twenty-Fifth Armies in the West, all showed fuel supplies at well below one consumption unit, meaning they would be unable to engage in mobile warfare once the Allies made new breakthroughs. Finally, in Italy, Kesselring informed Jodl that he had too little fuel, and that the situation there was approaching a climax.⁸⁶

⁸⁴ RG457, E9002, B12, "German Logistical Position: Notes by G-2 SHAEF as of 2 February," 7 February 1945, 1.

⁸⁵ Ibid., 2; AIR 40/2658, ULTRA (MSS) intercepts, Continuation of earlier list, intercepts for January and February 1945, AI3(c)2, 3 March 1945, 21 January intercept.

⁸⁶ RG457, E9002, B12, "German Logistical Position: Notes by G-2 SHAEF as of 8 March," 16 March 1945, 1-4; AIR 40/2658, ULTRA (MSS) intercepts, Continuation of earlier list, intercepts for January and February 1945, AI3(c)2, 3 March 1945, 28 February intercept. After the summer of 1944, only two German senior officers reported that they had adequate fuel supplies at any point. *Generalmajor* Dethleffsen stated that in general there was enough fuel for armored divisions in East Prussia until fuel had to be brought by sea starting in February 1945, while *Generalleutnant* Thomale, when asked about fuel shortages in the East, stated that "Everything was saved for the use of the armored divisions. Many armored divisions were to the last in Hungary and could be supplied through the fuel production there."

As grim as the situation was for army units, it paled in comparison with the difficulties faced by the Luftwaffe. German flying training hours for pilot candidates were 110 hours in combat types from July 1944 to the end of the war, compared with 360 for the USAAF and 340 for the RAF.⁸⁷ By December 1944 the Germans were turning out only one-third of the pilots planned for and required.⁸⁸ With an average of 4,345 operational aircraft assigned in January 1945, the Luftwaffe averaged only 740 sorties per day.⁸⁹ During the same month, only 13,000 tons of aviation fuel was released from the nearly-exhausted strategic reserve for pilot training.⁹⁰ In addition, there was almost no new aviation fuel being produced. By the beginning of February, Luftflotte 6 sent a message from the Eastern Front stating that its units were seriously hampered by lack of

See RG243, E31, B1, "USSBS Interview No. 19, Subject: Major General Dethleffsen" 9 June 1945, 5; and RG243, E31, B1, "USSBS Interview No. 20, Subject: Lt. Gen. Thomale," 9 June 1945, 9. The first statement does not square with a 17 November Ultra intercept, noted earlier, which said "Since August 1944 there has been an acute shortage of liquid fuel of every description in Army Group Nord. As a result, operations by Panzer Troops and Air Forces have been temporarily reduced to a minimum. Only some 100 aircraft have been operating daily in the whole of the area of Army Group Nord during this period...Officers in charge of liquid fuel supply claim that this shortage in area of Army Group Nord is temporary, and that the crisis will have passed by January 1945 because, by that time, three new synthetic fuel works will have started to produce." This intercept was noted in AIR 40/2073, AI3(e), "M.S.S. References to Oil Shortages and Restrictions since May 1944," 30 December 1944. We also know that the three new underground synthetic oil plants promised by OKW were never built, and that there was no relief in Army Group North's fuel crisis. Dethleffsen's comments were therefore either willfully inaccurate or simply mistaken. Thomale's statement regarding Hungary was correct because armored divisions there had direct access to a limited but adequate quantity of fuel from Hungarian oilfields and refineries. However, his answer was evasive and essentially a half-truth because Thomale ignored the obvious fact that along the two main Russian lines of advance—into Upper Silesia and towards the Oder River—German heavy divisions had very little fuel on hand, none in reserve, and only a trickle coming forward from the almost completely inoperative synthetic oil plants, the last few of which were systematically destroyed in the days leading up to the Russian winter offensive. The severe disruption of train schedules by the transportation offensive against the Reich further exacerbated fuel shortages in these key sectors of the front.

⁸⁷ SMS347, Addendum 1, B13, *The United States Strategic Bombing Survey Over-all Report*, 30 September 1945, 21, Chart 10. For the Germans, initial training in non-combat types was 90 hours for most of the war but dropped to 35 hours after July 1944. This meant *total* cockpit time for German combat pilots when assigned to their first combat unit was 145 hours after June 1944, as compared to about 450 hours of total cockpit time for USAAF and RAF pilots.

⁸⁸ AIR 40/2073, AI3(e), Script for Press Conference, 7 March 1945, 1-2.

⁸⁹ AIR 40/2073, AI3(b), "G.A.F. Activity—January 1945," 14 February 1945.

⁹⁰ AIR 40/2073, AI3(e), "G.A.F. Fuel Consumption: Estimate of Training Consumption," 3 January 1945.

fuel.⁹¹ As the Russian winter offensive got into high gear, forcing the Luftwaffe to use the last of its reserves, an order further restricted flying operations in the West owing to increased consumption of fuel in the East.⁹² A week later, cryptographers intercepted an OKW order to limit ruthlessly all Luftwaffe operations.⁹³ In a postwar interrogation, Göring noted that there had been a drastic reduction in the aviation fuel supply from 160,000 tons per month in March 1944 to between 15,000 and 20,000 tons per month by January 1945, which proved a decisive factor in the rapid operational decline of the Luftwaffe. By March 1945, Luftwaffe sorties in the East dropped from about 3,000 per day the previous summer to between 600 and 800 per day, with a surge capability of 1,200 per day for major operational requirements.⁹⁴

On 22 February, the CSTC noted with satisfaction that "The bulk of Germany's supplies of fuel for the next 4 to 6 weeks—at what may be a critical phase of the battle for Germany—will consist of the past production in transit through the distribution system."⁹⁵ This was a key development: While the Germans still had fuel in their distribution pipeline, it was so obstructed by heavy-bomber attacks against rail centers and bridges throughout the Reich that most German units received only enough fuel to conduct a static defense. In recognition of the fact that fuel production was nearly at an end, and that most remaining fuel was in the pipeline, the CSTC recommended that

⁹¹ AIR 40/2658, AI3(c)2, ULTRA (MSS) intercepts, Continuation of earlier list, intercepts for January and February 1945, 3 March 1945, 1 February intercept.

⁹² Ibid., 5 February intercept.

⁹³ Ibid., 13 February intercept.

⁹⁴ AIR 40/1345A, APWID 65/1945, Interrogation, "Hermann Goering," 1945, 18.

⁹⁵ MS16, S3, B5, F4, CSTC oil targets priority signal 8/45, 22 February 1945, 4.

attacks on fuel depots take precedence. German tactical mobility would be at an end once the depots were destroyed.⁹⁶

Given these disastrous German fuel shortages, the key requirement now, according to the Chiefs of Staff and the CSTC, was to give all possible support to the Red Army's offensive. Putting the last four Bergius plants out of action was vital because, along with the imminent Russian capture of Upper Silesia's synthetic oil plants and coalfields, it would cause a complete collapse of German oil production. Senior airmen also agreed to go after the marshalling yards through which German divisions moving to the East would have to travel, including those at Leipzig, Chemnitz, and Dresden. This proved to be another case of the synergy between the oil and transportation offensives.

Intelligence from Ultra sources confirmed that the 6th SS Panzer Army, comprised of four (and later six) SS Panzer divisions, was beginning a move from West to East with routing along the Berlin-Magdeburg-Leipzig-Dresden-Cottbus railways. Its orders were to stem the tide of the Red Army's advance into Upper Silesia and towards the Oder River. Significantly, the Russians had already begun pushing for major Allied bombing raids on all the major marshalling yards through which these units would have to pass. Ultra also provided detailed information on assembly areas in the vicinity of Cologne and Coblenz and the rate of movement, which the Germans projected at 25-30 trains per day. The most important use of heavy bombers at this juncture, Allied officers agreed, was to conduct heavy raids against marshalling yards in the West, where 6th SS Panzer was entraining, and rail centers where its units were most likely to transit or detrain. The

⁹⁶ Ibid.

Russian winter offensive had proven so successful that Allied leaders made these attacks their top priority after the last four functioning Bergius plants.⁹⁷

At a CSTC meeting in early February, the same topics received detailed attention. Allied heavy bombers would bomb cities in central and eastern Germany as a means of preventing movement of reinforcements to the East. Indeed, CSTC members, although they did not quote Clausewitz and had probably not read *On War*, nonetheless agreed that creating the greatest possible friction, *in the Clausewitzian sense*, was key:

The attack of these cities had been ordered, not merely because of their communications value or for any other single specific object, but because any additional chaos which we could cause at this juncture would make the German administrative and military problems, already immense, still more difficult.⁹⁸

The CSTC released its transportation targets list the following day, and Berlin, Dresden, Leipzig, and Chemnitz were high in the rankings, as were rail centers in the West where 6th SS Panzer Army was entraining. Only 27 marshalling yards appeared on this list, down from over 70 during the height of the transportation campaign. The others had all been damaged severely enough to warrant their removal from the list.⁹⁹ The CSTC then issued a supplemental list with five more targets. The rail centers to be raided in support of the Russian offensive thus came to include Berlin, Dresden, Chemnitz, Leipzig, Halle, Plauen, Dessau, Potsdam, and Erfurt. The supplemental list noted that "The following targets have been selected for their importance in relation to movements of evacuees from, and of military forces to, the Eastern Front."¹⁰⁰

⁹⁷ AIR 20/4819, Memo, AI3(E) to DBOps, "German Troop Movement from the Western Front to the East," 30 January 1945, 1-4.

⁹⁸ AIR 2/8011, Minutes, CSTC 16th Meeting held on 2 February 1945, 7 February 1945, 2. We should recall Clausewitz's view that "Action in war is like movement in a resistant element." (*On War*, 120).

⁹⁹ MS16, S3, B5, F4, "CSTC Communications targets priority signal No. 5/45," 8 February 1945.

¹⁰⁰ MS16, S3, B5, F4, CSTC Supplemental Target List, 8 February 1945.

Dresden, which has become an emotional touchstone for the brutality of Allied bombing, was indeed demolished in a series of devastating raids. What has been all but forgotten, however, is the fact that the Allies attacked Dresden and the other eight cities to speed the Red Army's advance and hence the end of the war. The BDA reports for these attacks noted the chaos caused by the raids. An ACIU K report and reconnaissance photos released days after the attack on Dresden showed severe damage to the main rail center, which was heavily loaded with locomotives and railcars. A large number of fires were burning there, in neighboring industrial concerns, and among adjacent POL storage (itself a vital target given the severe shortages by this point). Trains loaded with tanks and other vehicles had been heavily hit and were clearly visible in the photos attached to the K report, which noted that "great material damage" had been done. The roundhouse, central goods depot, and hundreds of railcars were destroyed.¹⁰¹

Brigadier General McDonald summed up the reasons for these raids:

The chief current target importance of these towns lies in their railway facilities. The Russian offensive has necessitated a tremendous movement of troops and supplies to the line of the Oder. At the same time the panic evacuation of civilians from the areas threatened by the Russians and the attempts by the enemy to rescue industrial equipment and machinery from the threatened areas had created a heavy traffic demand movement in the opposite direction. As a result rail activity in the whole area behind the front is intense.¹⁰²

McDonald noted the importance of Dresden and Chemnitz in particular as waypoints for the movement of German reinforcements to the Eastern Front. They also served as sources of fuel and ammunition. From the standpoint of military necessity, these raids, though brutal, appeared justified to senior Allied airmen. A report produced by the

¹⁰¹ AFHRA 168.7026-6, ACIU, Immediate Interpretation Report No.K.3742, 15 February 1945,

¹⁰² AFHRA 168.7026-6, Memo, McDonald to Spaatz, "Target Value of Berlin, Cottbus, Dresden, Chemnitz, February 1945," 19 February 1945, 1.

British Chiefs of Staff confirmed that bombing raids on these targets had slowed the movement of German divisions to the East.¹⁰³

As these attacks on key rail centers developed, bomber crews flying oil missions in early February knew their efforts had already reduced the production of finished POL products for January to 365,000 tons (27 percent of pre-attack capacity), while their focus on gasoline and aviation fuel had reduced production of these vital commodities to 100,000 tons (19 percent of pre-attack total).¹⁰⁴ Yet despite the many indicators that the oil offensive was succeeding remarkably well, there was no let-up in the pace of attacks. Clearly, the Allies were intent on ending the war as quickly as possible and with the lowest casualties, as these relentless attacks on the last remnants of the German oil industry indicated. For the week ending 12 February, there were sixteen major raids, including five on oil plants, seven on refineries, and four on depots. A last Bomber Command night precision raid, on Pölitz by 475 Lancasters dropping 1,657 tons of bombs, shut down the plant for the rest of the war.¹⁰⁵

Recent intelligence based on the analysis of fuel in captured vehicles on the Western Front showed a very heavy use of benzol as a motor fuel and a 15 percent alcohol blend in army fuels.¹⁰⁶ A SHAEF G-2 report noted that German gasoline now consisted of as much as 70 percent benzol. Calling for a relentless attack on benzol plants and fuel depots now that key gasoline producers were out of commission, the report said:

¹⁰³ AIR 8/1745, COS (45) 92, "Strategic Bombing in Relation to the Present Russian Offensive" (Note by VCAS), 1 February 1945, 1-3.

¹⁰⁴ MS16, S5, B8, F7, Working Committee (Oil Production and P.O.L. Depots), "Combined Strategic Targets Committee, Weekly Bulletin No. 1945-6," CSTC, 6 February 1945, 1.

¹⁰⁵ MS16, S3, B5, F4, CSTC Cable, "The oil offensive. Progress report no. 10. Week ending Feb. 12, 1945," CSTC, 15 February 1945, 1-2; Middlebrook and Everitt, *The Bomber Command War Diaries*, 661.

¹⁰⁶ MS16, S3, B5, F4, CSTC, "The oil offensive. Progress report no. 10. Week ending Feb. 12, 1945," 15 February 1945, 2-3.

Despite the fact that we are now nearing the end of winter it cannot be said that the enemy's fuel situation has been allowed to recover; instead the overall position is worse now than at any time previously...In fact the situation is currently worse than it has ever been; and it is no exaggeration to say that were operations to become mobile, the enemy would be helpless; being saved only by terrain and mud.¹⁰⁷

At the end of February the CSTC added another 20 small benzol producers in western Germany to its target list in an effort to destroy this industry.¹⁰⁸ A CSTC study indicating that German fuel production was not likely to top 40,000-50,000 tons per month after January made attacks on benzol plants even more vital because they were now the Germans' last source of fuel.¹⁰⁹ Another study noted that even a small benzol plant producing 500 tons (120,000 gallons) per month provided enough fuel to move a full-strength Panzergrenadier division 247 miles. In this study, H. C. Tett, Technical Chief of ESSO European Laboratories, noted that benzol resisted freezing to 0 degrees Fahrenheit, worked quite well with up to 40 percent alcohol content, had excellent anti-knock characteristics, and did not require the addition of tetraethyl lead (TEL), a rare commodity in the Reich by this time. In addition, Dr. E. B. Peck of the Office of the U.S. Petroleum Attaché, formerly with the Standard Oil Development Co., said the Germans could use 100 percent raw benzol as a motor fuel if necessary.¹¹⁰

As attacks on benzol plants got into high gear, the CSTC had finally concluded definitively that transportation attacks designed to interdict the movement of coal were having a disastrous impact on the German war economy—something they could have

¹⁰⁷ AIR 2/8011, SHAEF G-2, "Army Intelligence Review of Current Strategic Bombing Priorities," 19 February 1945, 1-2.

¹⁰⁸ MS16, S5, B8, F7, "Combined Strategic Targets Committee, Working Committee (Oil Production and P.O.L. Depots), Weekly Bulletin No. 1945-9," 27 February 1945, 3.

¹⁰⁹ MS16, S5, B8, F7, "Possible Future Trends in German Oil Production," 27 February 1945.

¹¹⁰ AIR 2/8011, EOU, "Notes on Benzol and the Oil Program," 1 March 1945, 1-4; Appendix A, "Memorandum from H. C. Tett, Technical Chief of ESSO European Laboratories" and "Memorandum from Dr. E. B. Peck, Office of U.S. Petroleum Attaché, formerly with Standard Oil Development Co."

confirmed four months earlier had they paid closer attention to BDA, Ultra intercepts, and POW interrogation reports. In late January and early February, they turned their full energies to maximizing damage to the German war economy even though oil targets still had top priority.¹¹¹ Heavy attacks on transportation targets, they said, would make more difficult "the immense task of re-orienting hard coal supplies from the Ruhr following the loss of the only other substantial source in Upper Silesia."¹¹²

As had been the case all along, SHAEF G-2 pushed the hardest for transportation attacks specifically to impede the movement of coal. A 19 February report noted that

Present evidence clearly indicates that the enemy's overall transportation situation is rapidly worsening as a result of bombing, loss of Silesian hard coal and the dislocation caused by the economic readjustment necessary as a result of the loss of Silesian industry, the biggest single blow at German economy since the war began... There seems to be little doubt therefore that the entire enemy industrial output is in grave jeopardy as a result of increasing inability of the enemy's communications, especially those leading to the Ruhr, to meet the demands made upon them. It seems, therefore, all the more urgent that as much effort as possible should be directed as soon as possible against the Ruhr communications.¹¹³

The report also stated that because Ruhr railways, canals, and coal mines were now more vital than ever, the CSTC recommended, and Bottomley and Spaatz approved, giving the attack of Ruhr transportation targets higher priority than any other targets except oil.¹¹⁴

The CSTC, now in full accord with SHAEF G-2, finally began building target lists to maximize the disruption of coal shipments. The Minutes of a 21 February meeting said:

Mr. Lawrence [of MEW] considered that the whole economic situation had changed recently in view of the loss to the Germans of Silesian industries, oil and coal. If we

¹¹¹ It was no coincidence that the CSTC turned its full attention to transportation attacks only after the oil offensive was largely and successfully completed by February 1945.

¹¹² Ibid., 3.

¹¹³ AIR 2/8011, SHAEF G-2, "Army Intelligence Review of Current Strategic Bombing Priorities," 19 February 1945, 1.

¹¹⁴ Ibid., 1-2.

could prevent the transportation of coal from the Ruhr, all organized rail operations elsewhere in Germany might be rendered impossible in a few weeks' time.¹¹⁵

By the following week the CSTC had concluded that it might be possible to reduce traffic between the Ruhr and the rest of Germany to 25 percent of pre-attack levels.¹¹⁶ The irony of these statements is that the disruption of coal shipments had already been severe simply because of the longstanding focus on attacking targets in the Ruhr, whether as part of the oil offensive or the transportation campaign. Also, and of the utmost importance, by this point *the German fuel position was so bad that it no longer mattered how many tanks, trucks, and aircraft German factories turned out.*

Transportation attacks continued to accelerate during the late winter and early spring. Coal exports from the Ruhr were down from 2,500,000 tons per month in March 1944 to at most 1,000,000 tons—and probably only 500,000 tons—by the beginning of March 1945. In addition, Bomber Command's elite groups had knocked out the Dortmund-Ems Canal once again. In the meantime, the 11th Panzer Division started a move from Trier to Cologne, a distance of less than 100 miles, on 13 February. As a result of heavy transportation attacks on rail centers in both cities, it did not begin arriving until 27 February and then had to be committed piecemeal. Transportation attacks had also contributed to a serious German ammunition shortage. And after nearly a year of concerted effort, heavy bombers destroyed the huge railroad viaduct at Bielefeld, over which much of the Ruhr's coal and steel passed. The Germans, resourceful as ever, had built a single-track bypass, but it was kept largely out of action.¹¹⁷

¹¹⁵ AIR 2/8011, Minutes, CSTC 19th Meeting held on 21 February 1945, 23 February 1945, 2.

¹¹⁶ AIR 2/8011, Minutes, CSTC 20th Meeting held on 2 March 1945, 2 March 1945, 5-7.

¹¹⁷ AIR 2/8011, Minutes, CSTC 21st Meeting held on 7 March 1945, 10 March 1945, 1-6.

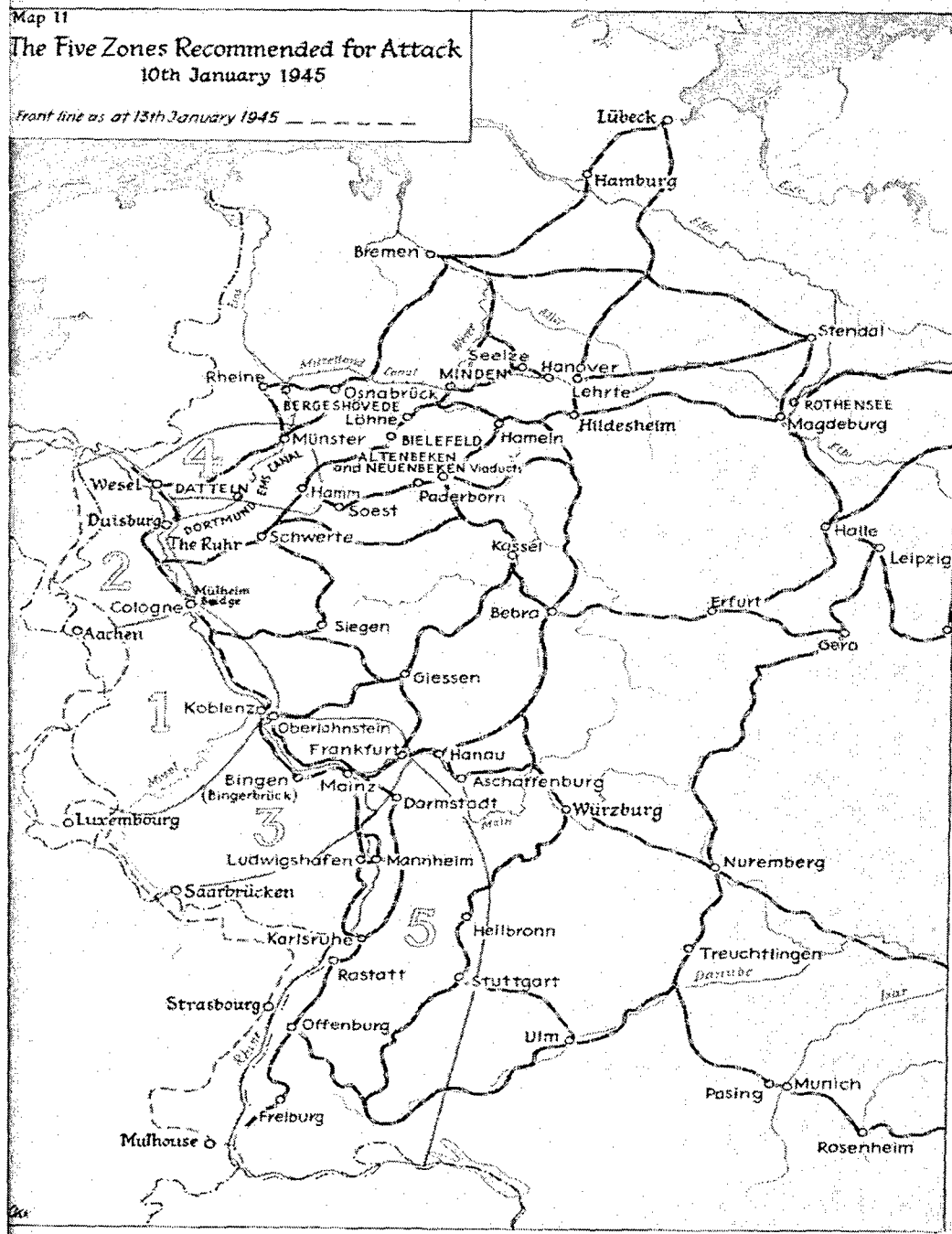


Figure 11.3: The Five-Zone Plan to Isolate the Ruhr, January 1945

Source: Sir Charles Webster and Noble Frankland, *The Strategic Air Offensive against Germany, 1939-1945, Volume III, Victory* (London: Her Majesty's Stationery Office, 1961), Map 11, 254.

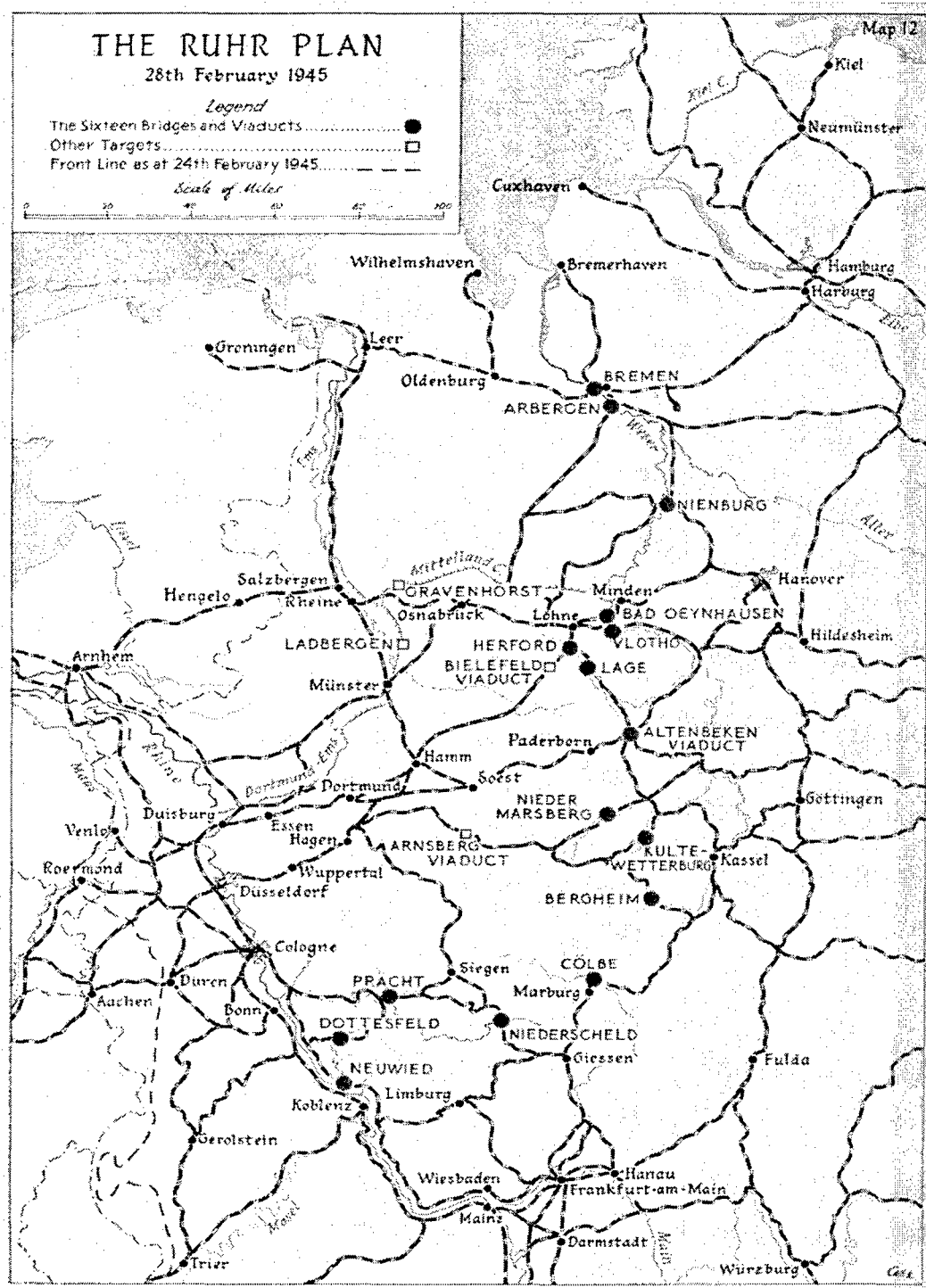


Figure 11.4: Plan to Isolate the Ruhr, Phase Two, February 1945

Source: Sir Charles Webster and Noble Frankland, *The Strategic Air Offensive against Germany, 1939-1945, Volume III, Victory* (London: Her Majesty's Stationery Office, 1961), Map 12, 255.

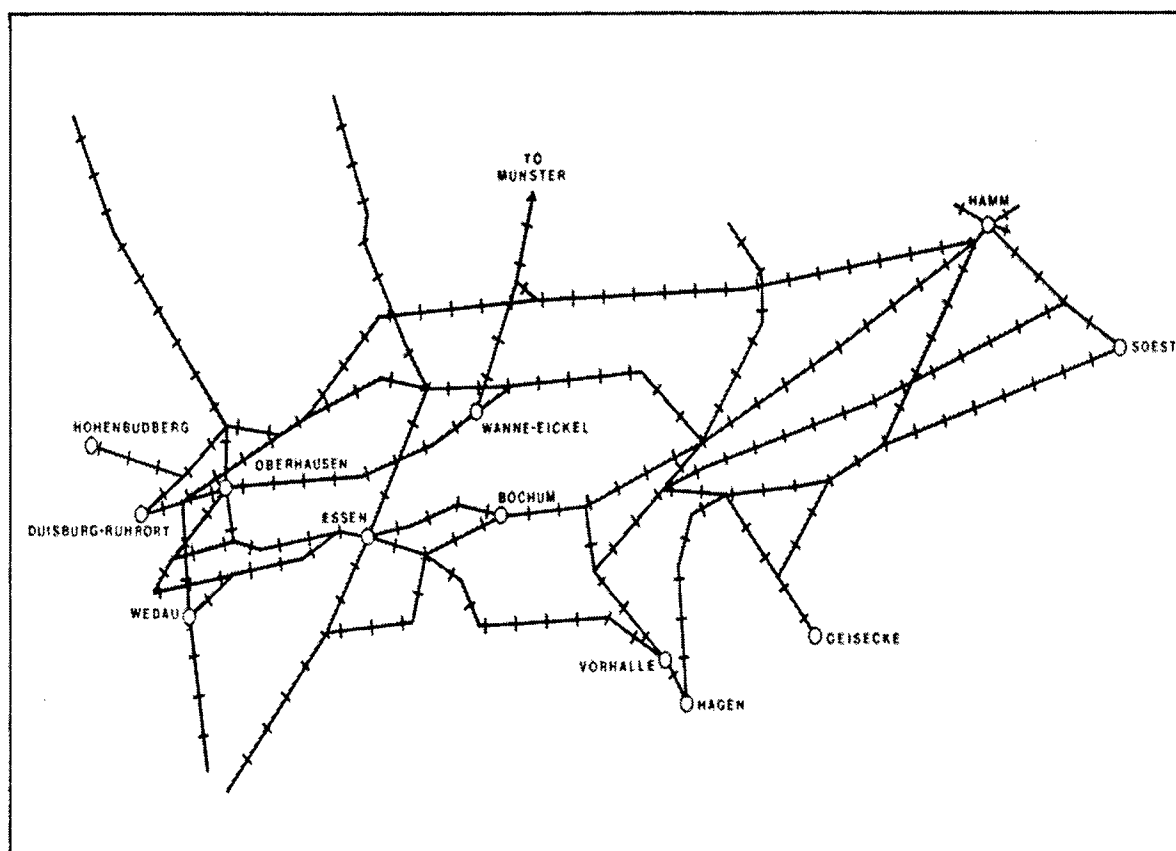


Figure 11.5: German Coal Gateways from the Ruhr

Source: Alfred C. Mierzejewski, *The Collapse of the German War Economy, 1944-1945: Allied Air Power and the German National Railway* (Chapel Hill, NC: The University of North Carolina Press, 1988), Map 3.3, 49.

As the CSTC tried to determine the damage to transportation networks, German POWs added their insights. Almost to a man, they noted the effectiveness of transportation attacks and related numerous instances of long delays in rail movement from one place to another. One said his unit's move from the Sudetenland to Cologne took 10 days (normally a two-day trip); another that trains from Heidelberg to Cologne (a distance of 135 miles) often took 10-12 days; and a third said he was supposed to leave Kassel for Cologne (a distance of 115 miles) on 5 January but did not leave until 19 January due to the havoc wrought by bombing on major marshalling yards. His journey then took 10 days to complete. It would have been quicker to march!¹¹⁸

As Germany's transportation system collapsed, so did her remaining oil production. By March all Bergius plants were out of action. Only the Ruhland and Harburg refineries were still operational. Benzol production was on the wane, with two-thirds of all benzol plants captured or out of action.¹¹⁹ Yet the Germans would not admit defeat. Repair efforts at Zeitz, which was assessed as permanently out of action, had the plant producing at 25 percent of capacity. It went back on the target list. This German tenacity prompted the CSTC to say "It was universally agreed that we should pursue oil to the last drop."¹²⁰ Heavy attacks the next week brought oil output to an all-time low. Production estimates

¹¹⁸ RG243, E36, B114, War Department, Report from Captured Personnel and Material Branch, Military Intelligence Division, "Expressions of Opinion of Recently Captured German Ps/W on Conditions at the Front and at Home," 17 March 1945, 1-3.

¹¹⁹ MS16, S3, B5, F2, CSTC, "The oil offensive. Progress report no. 13. Week ending 5 March 45," 7 March 1945, 3; MS16, S3, B5, F2, CSTC Target List, CSTC oil targets priority signal 10/45, 7 March 1945, 3.

¹²⁰ AIR 2/8011, Minutes, CSTC 23rd Meeting held on 21 March 1945, 25 March 1945, 2, 8.

for March were 250,000 tons of refined products (18.5 percent of pre-attack) of which only 50,000 tons was gasoline (9.5 percent of pre-attack).¹²¹ The CSTC noted that

In view of the success of the attack on [fuel] production the bulk of the enemy's inadequate supplies in the critical phase of mobile warfare now commencing will consist of whatever can be squeezed out of distributional stocks. Recent cover shows that efforts are being made to mobilize all such stocks. Experience of past attacks indicates that damage to the loading facilities at depots and to attendant pumping installations and pipe lines may effectively deny use of POL contained in them for some days or even a few weeks irrespective of the oil destroyed in tanks and loaded wagons.¹²²

The final phase of the oil offensive thus focused on denying German armies the remaining distributional stocks of gasoline at fuel depots. In fact, the rapid German collapse on all fronts had much to do with raids on these depots. One clear indication of this impending collapse was the 2 March supply report of the German Seventh Army *General Quartiermeister*, which stated that the army's three operational corps had 0.15 fuel consumption units, enough for their maneuver units to travel on average seven miles. This was the fuel position as the U.S. Third Army made its breakthrough to and across the Rhine. A SHAEF report said "Immobility through lack of fuel was undoubtedly a big factor in the defeat of the Seventh Army" as German units were surrounded and forced to surrender once they ran out of fuel in the offensive's opening days.¹²³

By April, with the capture of the Ruhr, benzol production collapsed, and with it went the very last vestiges of the German army's mobility. Fuel reserves had long since been exhausted, and the few units that found fuel never found enough to move more than a few miles. A JIC report said the lack of fuel was now *the* driver in German army operations:

¹²¹ MS16, S5, B8, F7, "Combined Strategic Targets Committee, Working Committee (Oil Production and P.O.L. Depots), Weekly Bulletin No. 1945-13," 27 March 1945, 1-6.

¹²² MS16, S3, B5, F2, CSTC oil targets priority signal 13/45, 29 March 1945, 2.

¹²³ RG457, E9002, B12, "German Fuel Position on the Western Front Since the Opening of the Allied Offensive in February: Summary by G-2 SHAEF on 21 March," 27 March 1945, 6-7.

The effects of the fuel shortages which have been imposed upon the enemy's land forces, while somewhat obscure when the western front was stable, have emerged as a major factor in the present phase of mobile warfare. The success of the Allied advances on the western front must be attributed largely to the enemy's lack of fuel which has not only prevented him competing in mobility and achieving any co-ordinated resistance, but has practically denied him the use against our spearheads of the considerable air forces still at his disposal."¹²⁴

This same problem had existed on the Eastern Front since June 1944. The war there was mobile, with few exceptions. From that point forward the lack of fuel proved disastrous.

By 17 April, the CSTC estimated that German production of finished POL products for the month would be no more than 100,000 tons (7.5 percent of the pre-attack total) of which only 20,000 tons would be fuel (4 percent of the pre-attack total). Their weekly report closed with the statement that "The strategic attack of oil has been virtually completed."¹²⁵ The minutes from a meeting of the CSTC held later that month included Bufton's high praise of the group's efforts, which he said "had taken the whole question of target selection for the Allied Strategic Air Forces from the stage of guesswork to that of Scientific method."¹²⁶ By the CSTC's 2 May meeting, enough German records, POWs, and oil plant managers had surfaced to confirm that BDA for the oil offensive had been exceptionally accurate. In fact, German records showed that Allied BDA reports were inaccurate for only one installation: the Eurotank crude oil refinery.¹²⁷

This note of triumphant closure was almost entirely absent for the transportation offensive. The key problem here—ironically—was a failure to grasp fully the devastation air attacks had inflicted on German railroads and inland waterways. Equally

¹²⁴ AIR 8/1018, JIC (45) 110 (O) Final, "Effects of Allied Attacks on the Enemy Oil Situation in Europe," 3 April 1945, 5 and also the one-page summation produced on 4 April 1945.

¹²⁵ MS16, S5, B8, F7, "Combined Strategic Targets Committee, Working Committee (Oil Production and P.O.L. Depots), Weekly Bulletin No. 1945-16," 17 April 1945, 1, 4.

¹²⁶ AIR 2/8011, 2286-2291, Minutes, CSTC 27th Meeting held 18 April 1945, 26 April 1945, 2.

¹²⁷ AIR 2/8011, 2296-2300, Minutes CSTC 28th Meeting (02051945) 11051945

problematic was the “whipsaw” effect in which bombers were required to go after three distinct types of transportation targets as tactical, operational, and military-strategic imperatives dictated. Bomber crews were never able to focus exclusively on targets chosen specifically to cause a collapse in coal shipments. In short, the demands of the ground war precluded the same kind of focus as occurred in the attack on oil.

Ironically, the CSTC finally seemed to grasp the enormity of the problem they had faced in assessing the aggregate effectiveness of transportation attacks during one of its final meetings, in which all the members lamented that “Transportation was a target system of a special type; the results of attacks upon this system were particularly difficult to measure quantitatively.”¹²⁸ This could not cover the failings of the CSTC in its efforts to gauge the effectiveness of transportation attacks, and to keep those attacks focused to the greatest extent on disrupting coal shipments. Yet it also reflected the frustrations of an air campaign in which bombers were constantly diverted from raids of a military-strategic character to those of an operational and tactical nature.

Nonetheless, transportation attacks, especially against rail centers and canals, almost always resulted in decreased coal shipments and war production. Although this was clear to BDA experts, the success of the transportation campaign against the Reich, unlike the oil offensive, became entirely clear only after VE Day. In fact, postwar interrogations proved vital in revealing the full extent of the transportation offensive’s effectiveness.

11.4 Contributions of *Ex Post Facto* BDA: The German View

Although BDA experts had a general idea of the damage bombers were doing to railroads and inland waterways, they failed to recognize several key developments that,

¹²⁸ AIR 2/8011, Minutes, CSTC 27th Meeting held on 18 April 1945, 26 April 1945, 4.

taken together, would have revealed the full extent of the catastrophe befalling German transportation networks by late 1944. To understand how shortcomings in the BDA effort hid the extent of the damage, we must look at what the Allies knew they had accomplished, and at what they did not know.

Just after VE Day, the Foreign Office produced a report entitled "Air Attack on the German Inland Communications System." Although it incorporated a few German sources, it was based largely on what BDA experts knew during the transportation campaign. It thus gives us a useful tool for examining what the Allies knew they had done to German railroads and inland waterways. They recognized that the transport situation in Germany deteriorated rapidly from the spring of 1944, as locomotives and rolling stock were lost in large numbers in the West and the East, the former due to Allied bombing and the latter to the Russian advance. Concerted raids on Ruhr transportation networks began in May 1944 and continued with increasing ferocity until April 1945. These complemented attacks in support of Overlord. In fact, raids on French and Belgian marshalling yards caused a decrease of 10 percent in the circulation of rolling stock in western Germany by July. The monthly allocation of rolling stock in Saarbrücken fell from 169,000 wagons in July to 51,000 in October, and the number of wagons dedicated to the Saar coal trade dropped from 5,000 to 1,100 per day in the same period. As attacks continued into October, the allocation of rolling stock to the Cologne Rail District fell 66 percent, from 205,000 wagons in August to 69,000 in October. These results, duplicated at most rail centers in western Germany, coal shipments.¹²⁹

¹²⁹ AIR 14/1229, Foreign Office (EAB4), "Air Attack on the German Inland Communications System," June 1945, 2-6.

Attacks on inland waterways, which began in late September, produced the same results, which became evident immediately to BDA specialists. The Dortmund-Ems and Mittelland Canals were rendered unusable until early November, and after that the Germans could only move a few days' worth of raw materials and supplies by water before the next round of attacks closed the canals again. Attacks on key canal locks and aqueducts kept river traffic at a low level after September. Barge traffic dropped from 24,000 tons per day in the pre-attack period to an average of 4,500 tons per day.¹³⁰

Heavy and systematic attacks against transportation networks began in November. Prior to this, most of the damage to railroads in western Germany was caused by missions flown at the behest of SHAEF for operational and tactical purposes. Now, the attack on German railroads and inland waterways *for military-strategic purposes* began in earnest. Speer's 11 November report to Hitler heralded the transportation crisis in the Ruhr. He said simply that coal could no longer be moved, produced, or stockpiled at factories in sufficient quantities.¹³¹

The first month's attacks reduced the circulation of rolling stock in western Germany from 549,228 wagons in November to 394,802 in December. The reason for this significant but not spectacular drop was that poor weather forced bomber crews to release all but 1,200 tons of the 18,000 dropped on marshalling yards during this period using H2X.¹³² However, in December the "whipsaw" effects discussed earlier reemerged with a vengeance as the Ardennes Offensive monopolized bombing sorties until the middle of January 1945. Nonetheless, the end result was a further drop in rail traffic in western

¹³⁰ Ibid., 6.

¹³¹ Ibid., 7.

¹³² Ibid.

Germany as bombers concentrated on marshalling yards bringing reinforcements and supplies to the front. In fact, attacks east of the Rhine ended organized rail shipments from the Saar and Cologne areas.¹³³ This made very clear the dual operational and military-strategic value of transportation attacks during the Ardennes Offensive.

As a result of transportation attacks, first in support of Allied ground forces during the Ardennes Offensive and once again for strategic purposes in January, total wagon circulation in western German rail districts fell 67 percent, from 183,018 in November to 83,658 in December. For the Saarbrücken rail district, a crucial coal transshipment area, the figures were 53,822 tons and 17,223 tons. Consequently, coal production dropped from 290,000 tons to 45,000 tons. It plunged much further in early 1945, culminating by March in the collapse of the German war economy. Too few trains arrived at the mines to cart away coal, so there was nowhere to store the mountains of ore that began piling up once trains stopped arriving on time or in adequate numbers. This had a catastrophic effect on weapons production and the rail movement of completed weapons, ammunition, fuel, and components.¹³⁴ BDA experts recognized these developments during the war.

This disastrous turn of events extended to inland waterways. The destruction of the Mühlheim bridge over the Rhine at Köln in early October rendered the river unusable to barge traffic for the next three months. Barge traffic passing through the Munster Locks on the Dortmund-Ems Canal declined from an average of 1,430,000 tons per month until September 1944 to 66,000 tons in February 1945, a decrease of 95.4 percent.¹³⁵

¹³³ Ibid., 11.

¹³⁴ Ibid., 11-12.

¹³⁵ Ibid., 16.

By March the wagon supply had fallen to one-eighth that of July 1944, deliveries of hard coal to one-fifth, of brown coal to one-half, and of steel production by four-fifths. The cascading effects of these shortages included failures in delivery of component parts to central locations for final assembly of weapons, and severe disruptions in the movements of weapons, ammunition, and fuel to the fighting fronts.¹³⁶ Once again, BDA experts recognized these developments during the war.

German records made clear the extent of the economic and military catastrophes brought on by transportation attacks. However, they also indicated that transportation attacks had harmed the war effort even more seriously than either damage assessments produced during the war or early postwar studies such as the one just summarized indicated. The wartime correspondence of Albert Speer made this glaringly clear.

Speer, who saw exactly what was happening and placed the transportation offensive second only to the oil offensive in its effects on the German war effort, bombarded Hitler and other senior Nazi leaders with memos detailing the damage inflicted and the consequences for war production. In a note to Hitler on 5 October 1944, Speer noted that in September 1943, 19,900 coal wagons moved daily in the Ruhr area. The figures for 3 and 4 October 1944 were 8,700 and 7,700 wagons, respectively. This, Speer told the Führer, was due entirely to air attacks, and it meant that coal stocks at industrial plants would be exhausted in 8-12 weeks. The result by winter would be "an extraordinarily severe coal and consequently a production crisis."¹³⁷ A month later, Speer warned *Reichsleiter* Martin Bormann that "Continued successful attacks on the transport system

¹³⁶ Ibid., 18-19.

¹³⁷ AIR 20/8779, Control Commission for Germany (BZ), Field Information Agency, Report No. 35, Appendix I, Memos, Speer to Hitler, 5 October 1944 – 15 March 1945, Memo No. 5, Speer to Hitler, A-1.

will result in a production catastrophe, which is of decisive importance to the continuance of the war.”¹³⁸ Less than a week later he told Hitler that “We are faced with the beginning of the most severe crisis in coal supply since the beginning of the war.”¹³⁹

To make matters worse, insufficient deliveries were reducing the *Reichsbahn*’s coal stocks by 40,000 tons per day. Electric power plants also saw a dramatic decrease in their coal stocks, from 1,237,000 tons on 1 September to 865,000 tons on 28 September. Gasworks in the Ruhr had less than 10 days’ supply of coal, several key ironworking plants were down to a three days’ supply, and many armament and food factories were on the point of stoppage. Speer warned: “For more than six weeks now the Ruhr has been virtually sealed off, to an increasing extent, from its markets through transport difficulties” while industrial coal stocks “will be exhausted by the end of November, unless a decided improvement in deliveries has been possible.”¹⁴⁰

Why, then, did coal shipments and the Reich’s war economy not collapse in the late fall of 1944? There were two key reasons. First, Spaatz and Bottomley viewed oil as a better target and gave it priority. Second, the Ardennes Offensive pulled bombers away from targets best suited to reduce coal deliveries. Mierzejewski made both of these points but carried the second one too far, downplaying the fact that many raids carried out during the German attack starved German armies of fuel and ammunition *and* damaged the rail centers through which much of the Reich’s coal moved.¹⁴¹ He also overlooked a

¹³⁸ Ibid., Memo No. 7, Speer to Bormann, 6 November 1944, A-2. Emphasis in original.

¹³⁹ Ibid., Memo No. 8, Speer to Hitler, 11 November 1944, A-2. Emphasis in original.

¹⁴⁰ Ibid. Emphasis in original.

¹⁴¹ See Mierzejewski, *The Collapse of the German War Economy*, 127, 153-54. Mierzejewski made the point that transportation attacks during the Ardennes Offensive unwittingly achieved this dual effect. He failed, however, to explore the ways in which a campaign dedicated specifically to disrupting coal shipments should have differed from, or could have improved upon, the admittedly *ad hoc* CSTC targeting

crucial dynamic at work in both the transportation and oil offensives, as did BDA experts at the time: Regardless of the intensity of heavy-bomber attacks, the German were always able to eke out enough fuel production or move enough trains to provide a bare minimum of fuel, coal, and component parts for weapons in between attacks. Given the bad weather of fall and winter, and the inaccuracies of blind-bombing aids, aircrews could not regularly achieve the accuracy required to keep rail centers entirely inoperative. Nor could reconnaissance aircraft reliably deliver post-strike cover. As Speer noted:

After the transport of coal by rail had fallen off, owing to traffic difficulties, its transportation by canal became decisive in the maintenance of industry in central Germany...It was possible to maintain industrial production in Germany on an emergency basis thanks to the fact that we always succeeded in pushing through emergency traffic [by rail and barge] for one or two days before the next attack.¹⁴²

Similarly, with respect to the oil offensive, Speer noted that there was always enough fuel for industrial purposes because an emergency ration of 60,000 tons per month of motor fuel and diesel allowed key industries to continue operating until the destruction of the railroad network in early 1945 caused a catastrophic drop in production.¹⁴³ Finally, Speer emphasized that a pause of only three days in bombing raids against the Ruhr allowed railroad workers to increase the daily allocation of wagons from 6,000 to 12,000.¹⁴⁴ This gave the *Reichsbahn* a number of temporary reprieves during the fall and winter of 1944-45, but as the Allies set up larger numbers of Gee-H and Micro-H towers on the

recommendations. Nor did he explore the synergy produced by continuing oil and transportation attacks during the Ardennes Offensive.

¹⁴² AIR 20/8779, Control Commission for Germany, Field Information Agency, "Examination of ex-Reichsminister Speer—Report 26, The Effects of Allied Bombing of Germany," in Combined Intelligence Objectives Sub-Committee Evaluation Report No. 219, 18 July 1945, 10.

¹⁴³ Ibid., 7.

¹⁴⁴ AIR 20/8780, Control Commission for Germany (BZ), Field Information Agency, Report No. 62, Interrogation of Albert Speer on "The Effects of Aerial Warfare and Allied Successes on German War Production," interviewed and provided material on 6 September 1945, report produced 8 November 1945, 21.

Continent, and began using large numbers of H2S Mark III and H2X sets by the beginning of 1945, these reprieves became less frequent and the bombing, even through cloud cover, increasingly accurate. Nonetheless, Speer's reminder that it was simply impossible to reduce fuel production and coal transport to nil was a vital one.

If Allied bombing was incapable of reducing German railcar placements and the movement of trains to nil, it did come increasingly close to doing so by 1945. As Speer noted, the severe damage done to marshalling yards, when combined with the destruction of signals equipment (telegraphs, telephones, and switching and signaling equipment), meant that even when trains were able to move, they were difficult to locate or reroute. This made it nearly impossible to track even the most vital consignments, including fuel trains. This was why Speer said "Transport difficulties were decisive in causing the swift breakdown of the Ardennes offensive."¹⁴⁵ *Generalfeldmarschall* Gerd von Rundstedt agreed. Noting that German troops involved in the attack started out with a two-day supply of gasoline, he said the combination of air attacks on all points of the fuel pipeline, poor roads, poorly-trained truck drivers, and the need to drive slowly and at night resulted in utterly inadequate fuel supplies. The cutting of railroad bridges in eight cities also "devastatingly contributed to the halting of the Ardennes Offensive."¹⁴⁶ This was another instance of synergy between transportation and oil attacks.

¹⁴⁵ AIR 20/8779, Control Commission for Germany, Field Information Agency, Technical, "Examination of ex-Reichsminister Speer—Report 26, The Effects of Allied Bombing of Germany," contained in Combined Intelligence Objectives Sub-Committee Evaluation Report No. 219, 18 July 1945, 9-10. Emphasis in original.

¹⁴⁶ RG243, E36, B244, HQ 12th Army Group, Mobile Field Interrogation Unit No. 4, interrogation of *Generalfeldmarschall* Gerd von Rundstedt, in "PW Intelligence Bulletin on Effects of US Strategic and Tactical Air Power," 20 May 1945, 9.

Yet another involved the use of a rapidly increasing number of “homogeneous trains” during the fall and winter of 1944-45. The problems created by the destruction of marshalling yards and railway signaling equipment forced the Germans to rely on this expedient, which involved loading an entire train with one item, whether it be fuel, ammunition, or component parts for shipment to central assembly points. It made the loading process at marshalling yards much easier, which was an absolute necessity given the reduced sorting and throughput capacities of these badly damaged installations and the breakdown of *Reichsbahn* command-and-control capabilities. However, it made re-supply efforts at the front much slower since these trains had to make multiple stops to deliver the one item they carried. This also meant a greater number of long-distance supply hauls by trucks shuttling back and forth between railhead and front since they had to make the drive more often to pick up the one item carried on each passing train. Nonetheless, said *Generalmajor* Peters, *Transportations Chef Nord*, “Sufficient traffic could be worked over these ‘night sections’ to meet the minimum essential requirements.”¹⁴⁷ What he did *not* mention was that his statement referred to requirements *in the aggregate*, which meant local shortages tended to be frequent and serious given the provision of a bare minimum of supplies. There is, however, no indication that BDA experts ever recognized these significant effects of transportation attacks on the German logistical situation in the West.

Nor is there any sign that they realized how disastrously transportation attacks impacted the Reich’s dispersed war industries. Postwar interrogations, however, made

¹⁴⁷ AIR 14/1229, CSDIC (UK), Interrogation of *General Major* Peters, Transportation Chef Nord in report entitled “Effect of Allied Bombing on the German Communication System, with Special Reference to the German Railways,” 1 September 1945, 2.

this point very clearly. As we have seen, Bomber Command's city raids made a major contribution to the Allied victory because they forced the rapid and far-reaching dispersal of war industries in 1943. Dr. Karl Otto Saur, who headed up Speer's Technical Office, said this was *the* major impact of bombing in 1943.¹⁴⁸ Hans Kehrl, head of Speer's Raw Materials and Planning Departments, said unfulfilled production due to lack of transportation of raw materials and components for final assembly at centralized factories was about 25 percent from June to October 1944, at least 60 percent from November 1944 to January 1945, and 90 percent from February to April 1945. He concluded that "The extensive dispersal of industry had a definitely unfavorable effect on the transport situation, especially in consequence of the decline in the marshalling facilities."¹⁴⁹

Something similar happened with the movement of ammunition from factory to front, but BDA experts also missed this development. The root of the problem, which proved disastrous by late 1944, lay in the tripartite division of ammunition production into components (e.g. casings and fuses), explosives and propellants, and the processing of these goods into completed ammunition. Items were shipped to more than 100 army assembly and storage depots for processing. This system was utterly dependent upon the rail movement of components. As the transportation offensive got into high gear, this inefficient and vulnerable process began to fail. Dietrich Stahl, the Industrial Director of Speer's Technical Department, noted that such a system, aside from its extreme

¹⁴⁸ AIR 20/8779, Control Commission for Germany, Field Information Agency, "Exploitation of ex-Reichsminister Albert Speer and members of the former Reichsministry for Armaments and War Production," Report No. 35, subject: "The Effects of Air Attacks on German Armament and Non-armament Production in the Ruhr," 1 October 1945, 8.

¹⁴⁹ AIR 20/8779, Control Commission for Germany, Field Information Agency, "Examination of Albert Speer and members of the German Reichsministry for Armaments and War Production," Report No. 34, Part IV, subject: "The effect of transport difficulties, due to air attacks, on overall production," 10 September 1945, 2.

vulnerability to disruption by air attack, “only made more difficult the overall control, the introduction of rationalized working methods and uniform responsibility.”¹⁵⁰ These German organizational inefficiencies made Allied bombing even more effective.¹⁵¹

General Buhle, the OKW *Quartiermeister General*, confirmed that ammunition supplies deteriorated rapidly after June 1944 due to dramatically increased consumption on all fronts, reduced production, and transportation difficulties (the latter two due to Allied bombing). He further stated that as a result of transportation attacks, only 70-80 percent of components reached depots at all, and completed ammunition often failed to reach the front due to destruction or delay by heavy-bomber attacks. Finally, Buhle said that as a result of transportation attacks, ammunition trains often sat for weeks on railroad sidings after the summer of 1944. “The whole ammunition production,” he concluded, “was seriously hit and crippled to such an extent that the armed forces could maintain only a very inadequate supply of ammunition.”¹⁵²

A similar set of woes, also overlooked by Allied BDA experts, was at work in the German armaments industry. Once again, a combination of heavy-bomber attacks and substandard production methods created severe problems in the movement of finished heavy weapons to the front. Incredibly, heavy weapons had to travel by train to four different locations: first to the ordnance depot for inspection and acceptance, then to the firing range for proper sighting, from there to the modifications depot for final improvements, and finally to the front. The period between completion of weapons and

¹⁵⁰ AIR 20/8780, Control Commission for Germany (BZ), Field Information Agency, “Examination of ex-Reichsminister Albert Speer and former members of the Reichsministry for Armaments and War Production,” Report No. 42, subject: “Ammunition Production in Germany,” 15 September 1945, 2.

¹⁵¹ *Ibid.*, 3-4.

¹⁵² RG243, E2, Box 59, USSBS Military Analysis Division, *The Impact of Allied Air Effort on German Logistics*, 2nd ed., January 1947, 82-85 and note 54.

their long and complex journey to the front increased greatly as a result of concerted transportation attacks.¹⁵³

In the end the Germans streamlined this convoluted system in January 1945. In this new process, gun ranging and final modifications were done at the factories, and delivery was then made to the fighting fronts. Similar reforms occurred in the ammunition industry, but they came too late.¹⁵⁴

The final and perhaps most intriguing oversight on the part of BDA experts as they sought to analyze the effects and effectiveness of the transportation offensive against the Reich was the utterly inane German practice of giving 90 percent of new heavy weapons to newly-formed units, which were appearing in droves by late 1944, mostly in the form of *Volks grenadier* divisions. The remaining 10 percent went to veteran divisions serving at the front—in other words, to the most capable soldiers in the German army and the ones in greatest need of new heavy weapons as their original ones were destroyed in combat or abandoned for lack of fuel. This disastrously misguided practice was evidently both a root cause of decreasing German combat effectiveness after August 1944 and one exacerbated by transportation attacks, which slowed or prohibited the arrival of the few heavy weapons received by veteran divisions. This was an unmitigated disaster brought on, once again, by a combination of German logistical and policy failings; high-intensity

¹⁵³ AIR 20/8779, Control Commission for Germany, Field Information Agency, "Examination of ex-Reichsminister Speer, Report 26, subject: "The Effects of Allied Bombing of Germany," Control Commission for Germany, interrogation on 18 July 1945, report produced 13 August 1945, 9.

¹⁵⁴ AIR 20/8779, Control Commission for Germany, Field Information Agency, "Examination of Albert Speer and members of the German Reichsministry for Armaments and War Production," Report No. 34, Part III, subject: "The Effect of Transport Difficulties on the End-production of Armaments," 10 September 1945, 2.

ground combat, which destroyed heavy weapons at a prodigious pace; and Allied bombing, which hindered the arrival of heavy weapons at the fighting fronts.¹⁵⁵

In comparing these oversights with the relative lack of such errors in BDA for the oil offensive, it becomes clear that the German oil industry simply lent itself to more accurate and comprehensive BDA than did the German transportation network, which was more complex, had to be engaged in a “whipsaw” fashion driven by events at the fighting fronts, and was simply less transparent in providing clues about the damage done by bombing raids. There were certainly enough BDA insights, as Mierzejewski has noted, to allow Allied senior airmen to recognize that the Germans faced a coal-transportation and war-production catastrophe as early as November 1944, but the Ardennes Offensive forced them to refocus their bomber crews’ energies on interdicting the movement of fuel, ammunition, and reinforcements towards the battle area. In addition, as Speer and others noted, the Germans were always able to move just enough gasoline, coal, component parts, and other critical items to keep the German war effort limping along through the fall and winter of 1944-45. However, once the final Allied and Russian drives on the Reich began in the spring of 1945, the full effects of the transportation and oil campaigns very quickly became evident. Above all, however, we must recognize that even though Allied BDA experts missed several vital indicators of

¹⁵⁵ RG243, E2, Box 59, USSBS Military Analysis Division, *The Impact of Allied Air Effort on German Logistics*, 2nd ed., January 1947, 9. The reasons for this bizarre policy are not clear but probably had to do with the larger German policy regarding the refitting of combat divisions. Unlike the American policy, in which replacements were constantly fed into combat divisions to keep them at or near full strength, the German practice was to fight their divisions until they were severely attrited *without* providing any replacements. Once divisions were judged to be no longer combat effective, their staffs were withdrawn and given new men and equipment with which they in effect rebuilt their divisions from the ground up. Robert Rush discussed this practice in some detail in *Hell in Hürtgen Forest: The Ordeal and Triumph of an American Infantry Regiment* (Lawrence, KS: University Press of Kansas, 2001), 7, 61-62.

the extent of damage to German transportation networks, they became steadily better at assessing the effects and effectiveness of Allied bombing.¹⁵⁶ And even in cases where they did miss key indicators, several of which we just addressed, their lack of insight did not by any means equate to a lack of tangible effects. In other words, the various effects of heavy-bomber attacks were real and often did grievous harm to the German war effort even though air intelligence analysts sometimes failed to recognize them.

¹⁵⁶ By late 1944, for example, SHAEF G-2 was producing an "Enemy Communications and Supply Summary" based on BDA reports from all available sources. It contained detailed assessments of the status of German railroads, inland waterways, roads, and logistical capabilities. The reports became more detailed and effective as the transportation offensive progressed. For example, see RG243, E36, B164, SHAEF G-2, "Enemy Communications and Supply Summary No. 31," 26 March 1945. This report contained the status of over 125 marshalling yards, 19 Ruhr railroad bridges, and 23 other railroad bridges.

CHAPTER 12

BDA IN RETROSPECT

*This, the most powerful air striking force in history, would be utterly blind without intelligence. It could not select targets, determine the proper composition of the attacking force, plan its route, or even assess the damage inflicted on the enemy.*¹

- HQ USSTAF Staff Study dated 24 October 1944

12.1 Summation: The Scope and Intensity of Bombing Operations

Two weeks before VE Day, Major General Fred Anderson, the USSTAF Deputy Commanding General, Colonel Lowell Weicker, his Deputy A-2, and Dr. Bruce Hopper, the USSTAF Historian, flew to the Continent in two aircraft loaded with two Jeeps, fuel, and rations "to inspect bomb damage in selected industrial areas of Germany in order to gain an impressionistic appraisal on the spot of the effectiveness of strategic bombing (both U.S. and R.A.F.)." Their tour lasted five days, from 17 to 22 April 1945. General Anderson's report on the visit painted the bomb damage they saw in dramatic but somber terms. The entry for Tuesday, 17 April, said: "Takeoff, 14:25 hrs, from air strip at Les Loges, in the C-45. 16:00 hrs, reach the Rhine at Bingen...bridges down, Mainz a shimmering shell. Sunken barges along the banks. 16:25 hrs, Frankfurt. Largely roofless. Looks like Pompei magnified. The city is shredded. Church spires and tall chimneys here and there, between which we weave." The entry for Friday, 20 April, related that at "13:00 hours...Jeeped to Leuna ruins. This plant produced 400,000 tons of

¹ HQ USSTAF Staff Study dated 24 October 1944, 1, in Spaatz Box 290, USSTAF A-2, "History of Directorate of Intelligence, United States Strategic Air Forces in Europe, January 1944 - May 1945," 8 September 1945.

synthetic oil a year; in 1945 it produced nothing. Here the rusted iron is like tropical undergrowth. A little white-faced chemist showed us around, reluctantly. He vowed he was disappointed in the Nazi Party; was surprised that the Americans broke through." Anderson's comments for Saturday, 21 April, reached a climax as he jeeped his way through the city made famous, and later infamous, for the Nazi Party rallies it hosted: "15:50 hours, Nuremberg, gutted and smoking...hardly anything but dust...This is super-annihilation, the *Gotterdammerung* comes to Nuremberg."²

Anderson had good reason to be both dramatic and somber. During the war, Allied bomber crews dropped 2,697,473 tons of bombs on Germany and her Axis allies. Of this total, the USAAF dropped 1,461,864 tons (54.2 percent) and the RAF 1,235,609 tons (45.8 percent).³ Bomber crews flew more than 1,400,000 sorties escorted by fighter pilots who flew another 2,680,000 sorties. At its peak, the air armada that carried the war to the Reich was comprised of over 28,000 aircraft. A total of 79,265 American and 79,281 British airmen were killed, the vast majority in heavy bombers. More than 18,000 American and 22,000 British aircraft were lost or damaged beyond repair. The costs for Germany were staggering: 3,600,000 dwellings—20 percent of all those in the country—were destroyed. Over 300,000 civilians were killed and another 780,000 wounded. The number of homeless reached 7,500,000 by war's end.⁴ As Anderson's report intimated,

² Spaatz Box 203, Major General Anderson, "Jeeping the Targets in the Country that Was," 25 April 1945, 1, 11, 15.

³ SMS347, Addendum 1, B13, *The United States Strategic Bombing Survey Over-all Report*, 30 September 1945, 2.

⁴ MS16, S5, B12, F14, *The United States Strategic Bombing Survey Summary Report (European War)*, 30 September 1945, 1. For total casualties suffered by heavy-bomber crews, see Martin Middlebrook and Chris Everitt, *The Bomber Command War Diaries*, 708, which notes that Bomber Command lost 73,741 men, or 93 percent of total British air casualties. On the American side, heavy-bomber losses were 67,646 men killed, 85.3 percent of the total. See USSBS, *Statistical Appendix*, 1, Table 1, and USSBS *Summary Report*, 2-3. As for bomb tonnage, the same source documents note that USAAF heavy bombers dropped

Germany's cities lay in ruins, its industry was prostrate, and its people were utterly stunned and demoralized. Most of all, however, her oil plants, trains, barges, and war industries, and therefore her armies, had ground to a halt under the relentless hammering of Allied heavy-bomber attacks. If the wreckage of the Third Reich's cities was the most dramatic sign of its defeat, the wreckage of its oil plants and refineries, marshalling yards, canals, armies, and air forces was the most important.

These aggregate figures paint a stark picture of the Allied bombing effort's material and human costs. In the six decades that have passed since the end of the war, arguments among scholars still rage back and forth about the bombing campaign's effectiveness as an instrument for helping to bring about Germany's defeat, and much agonizing over bombing's moral implications continues to this day. However, as recent scholarship has engaged with new sources and employed new methodologies to assess the effects and effectiveness of the Allied bombing effort, an increasing number of eminent military historians have arrived at the conclusion that the effort, brutal and costly though it was, nevertheless played a decisive role in the Allied victory, and, despite the moral issues surrounding it, was nonetheless justifiable given the circumstances surrounding its employment against an extremely brutal and aggressive Nazi regime bent on the conquest first of Europe, and eventually most or all of the world's other continents. The emerging consensus among scholars, therefore, is that the Allied bombing of Germany and the other European Axis powers, although extraordinarily destructive and at times brutal in its application, was nevertheless a vital element of Allied strategy and represented the

1,005,091 tons, 68.7 percent of the total dropped by American aircraft in Europe. For Bomber Command, the total was 955,044 tons, 77.3 percent of the total dropped by British aircraft in Europe. See Middlebrook and Everitt, *Bomber Command War Diaries*, 707.

only way in which the British and Americans could bring major military strength to bear against the Axis in a concerted fashion prior to the Normandy campaign.⁵

This work has arrived at the same basic conclusions, but from a different direction. It began where most of the recent scholarship left off, looking not only at bombing's effects, but at what Allied air commanders knew of them at the time and how that shaped their decisions. It has also carried the analysis beyond Normandy and the Western Front to encompass bombing's effects on the Eastern Front, and in particular its influence on ground operations from D-Day to VE Day. In a larger sense, then, this work has sought to do more than simply assess the effects and effectiveness of Allied bombing in Europe. Rather, it has sought to provide an understanding of the Anglo-American BDA

⁵ See Chapter 1 for the historiography that addresses these issues. Arguments put forth by John Kenneth Galbraith and other critics of Allied bombing have been thoroughly debunked by the superb work of Richard Overy, Williamson Murray and Alan R. Millett, Alfred Mierzejewski, and Gerhard Weinberg, among others. Galbraith provided a brief recapitulation of his views in "Peace through Patience, Not Air Power," *The New York Times*, 25 April 1999, when he noted, as part of a larger attack on the air campaign in Kosovo, "Fifty-four years ago this month, I became the director for overall effects of the United States Strategic Bombing Survey. After some months of work with a talented staff, the interrogation of Albert Speer and other German officials and the examination of excellent German records, we concluded that the great strategic air attacks had not appreciably reduced German war production. Nor had they effectively shortened the war. That was won by ground troops with tactical air support up from Normandy and across the vast plains of Russia." Obviously, he either did not read or simply chose to ignore the mountain of evidence in wartime BDA reports, ground-survey reports, POW interrogations, and a variety of other sources, all of which made it abundantly clear that his measure of merit, industrial production, was irrelevant. As a result of the oil offensive, there was hardly any fuel for any of these weapons by late 1944. Galbraith's comment that tactical air forces and ground forces did all the work indicates that he overlooked entirely the synergy between heavy-bomber attacks on marshalling yards, heavy-bomber and medium-bomber attacks on bridges, and fighter-bomber and night-bomber attacks on troop and supply columns forced to road march from the distant railheads. He also missed entirely the dramatic influence of the oil and transportation campaigns on the Eastern Front. Galbraith also ignored the indispensable role of Operation Argument—the sustained USAAF attack on the Luftwaffe—in winning air superiority over Europe, which was the indispensable precursor not only to the transportation and oil campaigns, but also to the highly successful ground campaigns from D-Day to VE Day. By drawing 70 percent of fighters to the air defense of the Reich and forcing a drastic shift from bomber to fighter production, this effort resulted in the German loss of air superiority on every fighting front and a severe shortage of bombers to provide direct support to German armies. Finally, Galbraith showed a stunning inability or unwillingness to acknowledge the myriad of sources indicating that oil and transportation attacks had in large measure undermined the German military's ability to mass, maneuver, and fight major battles.

intellectual infrastructure, the analysts and photointerpreters working within it, and the ways in which they provided vital insights to senior airmen. These insights allowed decision-makers such as Spaatz and Bottomley to steer USAAF and RAF bombers to the proper targets and thereby do the greatest possible damage to key target sets throughout Germany and occupied Europe. This attempt to approach the air war from an intelligence perspective has illuminated a number of important issues surrounding the bombing effort that had previously been either largely or entirely absent in existing scholarship.

First and foremost among these, as we have seen, is the indisputable fact that the air intelligence effort paid huge dividends in discerning, targeting, and then assessing the damage to German oil and transportation assets, which proved to be the Reich's two most vital target sets. Ironically, less than half of the total bomb tonnage dropped on Axis and occupied Europe—47.4 percent to be exact—fell on these two target sets: 36.3 percent on transportation targets and 11.1 percent on oil targets. The rest fell on military targets, including U-boat pens and V-weapon launching sites (11.1 percent); chemical and rubber targets (9.3 percent); airfields (6.8 percent); and other targets (12.7 percent).⁶

Nonetheless, it is not too much to say that air intelligence gave senior airmen the insights they needed to wage an increasingly effective bombing campaign against the Reich. To employ a biological analogy, if the heavy bombers, aerial munitions, and aircrews involved in this process provided the muscle, bone, and tendons—in other words, the body—required for this effort, and the senior airmen commanding them represented the brain, air intelligence provided the senses—sight, hearing, smell, touch, taste—upon

⁶ SMS347, Addendum 1, B13, *The United States Strategic Bombing Survey Over-all Report*, 30 September 1945, 2, Chart 1.

which the brain and the body depended. Without an effective targeting and BDA effort supporting it, Allied bombing would have been at best ineffective and at worst an unmitigated disaster. The thousands of air intelligence personnel and the hundreds of photoreconnaissance aircraft involved in assessing the effects and effectiveness of Allied bombing, and the larger organizational and intellectual infrastructures within which they worked, played an integral role in the transportation and oil campaigns, and in the earlier effort to gain air supremacy in the skies over the Third Reich. Without them, these campaigns could not have been brought to such successful conclusions.⁷

As we have seen, only a tiny percentage of total bomb tonnage hit vital components within the transportation and oil target sets, but it was enough to destroy both in the 14 months from the start of the transportation offensive in France and Belgium to VE Day. Indeed, the damage done to these vital target sets undermined the German war effort at the tactical, operational, and military-strategic levels by making it increasingly difficult, and ultimately impossible, for German armies and air forces in the field to mass and maneuver on a large scale. Nonetheless, the bombing effort was far from perfect, and the BDA effort also had its flaws, several of which were significant and reduced the effectiveness of the major bombing campaigns, particularly in the case of transportation attacks against the Reich. At the same time, we cannot help but be deeply impressed by the effectiveness of BDA in the aggregate. It most nearly approached perfection during

⁷ The contrast between Allied and Axis emphases on air intelligence is stunning. Despite the fact that they had several outstanding reconnaissance aircraft and cameras, the Germans never developed an effective military-strategic air intelligence capability. This was most evident in their abject failure to employ reconnaissance assets to gain a full appreciation of the Soviet Union's ability to wage war. As we now know, however, the Germans were generally unwilling to allow reality to impinge on their ideas of what was possible at the grand-strategic, military-strategic, and operational levels of war. Their failure to develop effective air intelligence and reconnaissance capabilities is a case in point.

the attack on oil, which was, after all, a target set ideally suited to concerted attacks by heavy bombers. The damage-assessment process for transportation attacks on French and Belgian railroads and canals was only slightly less effective. Here again, the nature of the target set proved crucial. The objective was quite simply to isolate the Normandy battle area as completely as possible from German re-supply and reinforcements. This meant destroying a set number of marshalling yards, bridges, and (once the Allies recognized their importance) canals.

The BDA effort for transportation attacks against the Third Reich itself was somewhat less effective for reasons discussed in the previous chapter. The most important of these was simply the “whipsaw” effect generated by the constantly shifting requirements to carry out attacks at the military-strategic, operational, or tactical levels as the ground campaign developed. Also important was the simple fact that the majority of senior air and ground commanders viewed oil as the most vital target set and transportation a close second. The CSTC’s lack of focus was indeed problematic, as Mierzejewski noted, but we must not forget that they, too, were prisoners of these larger contextual factors. They also had to work, as did Bottomley and Spaatz, with a heavy-bomber force which, although huge by the spring of 1944, was nonetheless hampered by a combination of technological limitations and Europe’s bad weather. The CSTC could recommend the best targets, something they managed to do most of the time, but beyond that the vagaries of the weather and the shortcomings of the relatively rudimentary navigation and blind-bombing instruments available at the time determined how accurately and often aircrews hit a given target. These inherent limitations usually gave the Germans enough time between attacks to eke out small amounts of fuel, coal, and

component parts and deliver them to fighting front and factory. The relentless attacks and superb BDA drove down oil production, train and barge movements, coal production and shipments, and war production inexorably, but they could not cause a complete collapse overnight. German repair expertise and tenacity only added to the difficulties involved. In the end, though, the Third Reich's oil production and transportation networks did collapse, and they did so in large part as a result of outstanding Allied targeting and BDA efforts. Indeed, by 1944 the targeting-bombing-BDA feedback loop was strong, and it became stronger as the transportation and oil attacks progressed.

12.2 Synergy, Serendipity, and Missed Opportunities: The Transportation and Oil Offensives in Retrospect

Looking back at the last three bombing campaigns of the Second World War—the transportation offensive against French and Belgian railroads and canals, the oil offensive, and the transportation campaign against the Third Reich itself—we can draw some general conclusions about their effectiveness and the role they played in securing the Allied victory. The first of these, which involved concerted attacks on French and Belgian railroads and (somewhat belatedly) canals, was a striking success. As we discussed in Chapter 9, this offensive was built on two absolutely vital foundations. The first, and most obvious, was a huge Allied air armada that included over 4,000 heavy bombers by the spring of 1944 and had by that time gained air supremacy in the skies over the Reich and occupied Europe. The second and no less vital foundation, but one largely overlooked by scholars, was the superb air and economic intelligence capability the Allies fielded by early 1944. From a humble beginning in early 1940 with one dedicated photoreconnaissance Spitfire and the Aircraft Operating Company, the RAF's

photoreconnaissance squadrons and the ACIU had by 1943 become absolutely superb BDA providers. Even more important, they were only part of a much larger, highly integrated, and exceptionally capable collection of agencies, including the Air Ministry, RE8, MEW, RRS, and EOU, which together comprised a mature intellectual infrastructure. On the whole, these agencies worked well together, sharing their expertise and insights freely, and calling frequently on outside civilian expertise from the oil and transportation industries as they planned and assessed the effects and effectiveness of the three major campaigns in question.

These agencies did more than merely assess the effects and effectiveness of heavy-bomber raids. They also helped to plan air campaigns and, through the CSTC and its predecessors, made targeting recommendations to senior airmen based on the latest BDA reports. It was this ability to make reasoned and, on the whole, accurate judgments about these air campaigns that was at the core of the organizational, technological, and procedural prowess comprising the intellectual infrastructure that emerged early in the war and reached maturity in early 1944. This unique capability, born of necessity but also built on the rationalist, scientific, capitalist, and ideological foundations of the West, and in particular of Great Britain and the United States, gave Allied airmen the insights they required to steer their heavy-bomber forces to the most lucrative targets.

This ability to engage the targets most likely to undermine the German war effort first became clear with the concerted assault on the Luftwaffe and its bases of supply that began with Operation Argument and continued without letup for the rest of the war. It came into much sharper focus, however, with the transportation campaign against French and Belgian railroads and canals. The influence of expert civilian advisors such as

Professor Solly Zuckerman and Mr. Brant, and of particularly capable airmen such as Tedder and Spaatz, on the planning for and execution of this campaign was obvious—and obviously beneficial—from the outset. Zuckerman in particular played the preeminent role in the iterative learning process that began on a small scale with railroad attacks in North Africa, matured with the careful study of the transportation campaign in Italy, and came to fruition in the campaign against French and Belgian transportation assets. The closely related abilities to discern key enemy vulnerabilities, plan an air campaign to exploit them, and monitor with great precision the effects and effectiveness of heavy-bomber raids in such an effort, came together completely for the first time in the bombing raids supporting Overlord.

Several key strengths become evident when we look at this campaign. First and foremost was the dual role played by targeting and BDA. Had either one of these critical air intelligence functions been found wanting, the offensive would have been much less effective than it was. Indeed, the Germans were able to exploit the loopholes created by the few weaknesses in the targeting effort, most notably the failure to attack canals and barge traffic from the outset. Despite the very difficult and time-consuming process involved in road marching their combat divisions to these canals, loading their equipment and troops on barges, and then unloading and marching to the front once across the Seine and Loire Rivers, the Germans nonetheless moved a significant number of men and large quantities of fuel and ammunition into Normandy in this fashion. It took SAS and Maquis teams on the ground to recognize what was happening, and it was the intelligence they provided that finally closed this targeting loophole and brought barge traffic under heavy and concerted attack along with the French and Belgian railroad networks.

Equally important was the committee process employed to recommend the most important targets for attack. This uniquely Allied process had its start in the Jockey Committee established in 1943 to recommend targets for the campaign against the Luftwaffe and its sources of supply. The process matured in the spring of 1944 with the establishment of the Railway Targets Committee (RTC) and the Joint Oil Targets Committee (JOTC) to recommend targets and release weekly prioritized target lists for the transportation campaign in France and Belgium as well as the oil offensive. These standing committees (and their successors, the CSTC's oil, communications, and Jockey working committees) gave senior airmen the insights they needed to steer heavy bombers to the most lucrative targets.

A third key Allied BDA capability was represented by the RRS and its expert civilian advisors. This Allied ability both to train the very best military analysts and photointerpreters, often drafted from civilian jobs in which they performed similar tasks, and bring them together with the foremost civilian experts for a given industry paid huge dividends for the success of Allied heavy-bomber campaigns. In the case of air attacks on the French and Belgian railroads, and later on the *Reichsbahn*, the RRS and its civilian advisors played a central role. The crucial issue to bear in mind here is that air intelligence agencies trained military BDA experts *and* actively sought outside civilian expertise to assist with the targeting process and BDA efforts.

Finally, the campaign in France benefited immensely from the iterative learning process forged by Zuckerman and Tedder and then employed for the remainder of the war. This gave Allied BDA experts an opportunity to see how effective their damage assessments had been during the course of a given campaign by comparing them with

captured records, POW interrogations, and testimony from workers and senior officials. This process worked remarkably well for the transportation campaign in France and Belgium, which drew not only on experiences in Italy but also on captured French and German railroad records, ground survey reports, and insights from French railway officials and workers, all of which the Allies then used to build a less effective but nonetheless decisive transportation campaign against the Reich.

The same set of dynamics was at play for the oil offensive. As the USSBS noted, oil experts understood clearly that “The Germans waged World War II with oil, chemicals, rubber, and explosives made largely from coal, air, and water.”⁸ Consequently, they also recognized that a campaign against oil plants would pay huge dividends in two ways. The first was by reducing oil and fuel production. The second was by undermining the production of nitrogen and methanol, chemicals vital to the production of explosives and ammunition, which occurred almost entirely at synthetic oil plants. The shortages of fuel *and* ammunition resulting from the oil offensive and the logistical disruptions caused by the transportation campaign reduced the German army’s ability to oppose Allied advances on three fronts. The battles in Normandy and on the Eastern Front in the summer of 1944 involved an enormous consumption of explosives at a time when production was dropping catastrophically and reserve stocks, never large, were being rapidly exhausted. The USSBS Oil Report concluded that “Bombing of the nitrogen industry was effective and decisive. It was a byproduct of the bombing of synthetic oil.”⁹ In a 30 August memo to the Führer, Speer warned that “The effect on the entire chemical

⁸ Ibid., 10.

⁹ SMS347, Addendum 1, B13, *The United States Strategic Bombing Survey Over-all Report*, 30 September 1945, 51.

sector has become formidable as a result of these renewed [bomber] attacks, as the most severe shortages are becoming evident, not only in fuels, but also in various important fields of chemicals..." including methanol and nitrogen for ammunition production.¹⁰

Just how severely nitrogen production was affected by the oil offensive becomes clear when we consider that it dropped from about 80,000 tons in April 1944 to 19,000 tons in December. From there, it plummeted to nearly nothing by April 1945.¹¹ Powder production peaked at just over 26,000 tons in April 1944 and began a steep decline from there, just at the moment when consumption reached nearly 40,000 tons per month in the heavy fighting of summer and fall. If the precipitous decrease in nitrogen production was a second-order effect of the Allied bombing of synthetic oil plants, the rapid drop in powder, which relied on nitrogen production, was a third-order effect, and the ammunition shortages on all the fighting fronts, which grew steadily worse after summer 1944, must be viewed as a fourth-order effect that was also due in large measure to the breakdown of the German transportation network.¹² Total explosives production, reliant in large measure on nitrogen output, also dropped precipitously, from just over 55,000 tons in June 1944 to just under 20,000 tons by February 1945.¹³

Despite the synergistic and serendipitous relationship between the oil offensive and the reduction of German explosives and ammunition production, and the disruption in deliveries of these vital supplies as a result of transportation attacks, there is no doubt that

¹⁰ AIR 20/8780, Control Commission for Germany (BZ), Field Information Agency, Report No. 62, Interrogation of Albert Speer on "The Effects of Aerial Warfare and Allied Successes on German War Production" (interviewed on 6 September 1945), 8 November 1945, 9.

¹¹ SMS347, Addendum 1, B13, *The United States Strategic Bombing Survey Over-all Report*, 30 September 1945, 52, Chart 19.

¹² *Ibid.*, 55, Chart 21.

¹³ *Ibid.*, 57, Chart 23.

the Allies should have targeted the powder and explosives industry *in addition to* oil rather than simply as an adjunct to it. There were 35 large explosives and propellant plants, seven of which produced 70 percent of Germany's total output. Going after these plants in conjunction with attacks on synthetic oil plants would have robbed the Germans of both the raw materials *and* the productive capacity to convert them into explosives and propellants. Had anybody at the Air Ministry read Lord Tiverton's plan for the destruction of these vital German assets during the Great War, things might have been very different. Unfortunately, Tiverton's plan, and virtually every other useful targeting and BDA insight from the First World War, never saw the light of day until well after the end of World War II. A postwar investigation of these explosives and propellant plants showed that they were vulnerable to air attack and that recuperation would have been slow, taking six to nine months to restore a badly damaged plant to full production.¹⁴ Indeed, Albert Speer emphasized after the war that such an attack would have produced "a standstill in powder and explosives manufacture."¹⁵

One other oversight in the oil offensive was the failure to attack the only three plants—two in Germany and one in France—making ethyl fluid, comprised of tetraethyl lead and ethylene dibromide, which was an indispensable component in aviation fuel. There was no substitute for these materials, the factories were highly vulnerable to heavy damage, and the Germans could not build new plants quickly because they were as complex and nearly as large as synthetic oil plants. None of the three plants was ever

¹⁴ Ibid., 58.

¹⁵ AIR 20/8779, Control Commission for Germany, Field Information Agency, "Examination of ex-Reichsminister Speer—Report 26," 13 August 1945, 13. Based on Speer's answers to a questionnaire entitled "The Effects of Allied Bombing of Germany."

bombed. This was one major opportunity the Allies missed altogether.¹⁶ As it turned out, the oil offensive knocked out German aviation fuel production quickly, but it could have done so even faster with attacks on these three plants.

Albert Speer noted another shortcoming in oil attacks during a postwar interview:

It was our good luck that you always gave us a little [more] time between attacks than we needed for reconstructions so that it was possible for us to maintain production for a short time. Your attacks were repeated approximately every eight weeks. I needed approximately six weeks for reconstruction.¹⁷

He also noted that American bombs were too small and fused with too much delay to cause major and lasting damage, while the 4,000-lb. British bombs, incendiaries, and delayed-action bombs had devastating effects on oil plants as well as repair efforts.

Nonetheless, Speer was also very clear about the oil offensive's decisive impact on the ground campaign, stating that it played a vital role in the speed of the Allied victory:

Summarizing the situation I have to say that seen from my side of the picture the American attacks with the effect as of May 1944 brought about the decision of the war, the attacks on the hydrogenation plants were so extensive that our troops on the front could not be supplied with the necessary amount of fuel. Even without the supply from Rumania we would have been in a position to keep the troops supplied with fuel, possibly this material would have been a little scarce. Without the attacks we could have maintained a constant flow of fuel to the front.¹⁸

Speer's meaning here was clear and crucial. Once oil attacks reduced fuel production and transportation attacks disrupted the distribution pipeline in the late summer of 1944, supplies of fuel to all the fighting fronts were unreliable in terms of delivery times and locations, and insufficient in terms of amounts delivered. In fact, the synergy between oil and transportation attacks exacerbated this problem dramatically. Nonetheless, Speer

¹⁶ Ibid., 45.

¹⁷ RG243, E31, B1, "USSBS Interview No. 11, Subject: Reichsminister Albert Speer, 31 May 1945, based on Minutes of 19 May 1945 interrogation, 3.

¹⁸ Ibid., 9.

noted explicitly that an earlier and greater effort against oil plants and refineries would have ended the war even sooner.¹⁹

Be that as it may, the Allies engaged in a concerted and heavy bombing effort once they went after oil targets. Up to May 1944, heavy-bomber crews had dropped 509,206 tons of bombs on enemy targets, but only 5,670 tons (1.1 percent) were expended on oil targets. From 12 May 1944 to 8 May 1945, they dropped 191,256 tons on 87 German oil-producing targets (16 hydrogenation plants, 9 Fischer-Tropsch plants, 40 refineries, and 22 benzol plants). They made a total of 273 raids on synthetic oil plants alone between May 1944 and April 1945 comprising 61,712 sorties. It is also significant that Bomber Command crews flew 109 of these raids. Given the much greater bomb tonnage delivered by Bomber Command missions, it becomes clear that the British deserve at least equal credit for the oil offensive's success, particularly in view of the fact that they did not join in until July 1944. The vital importance of Bomber Command's contribution becomes even clearer when we consider the accuracy of various bombing methods against oil targets. When bombing visually, 8th Air Force crews put 26.8 percent of their bombs within the grounds of German oil plants and refineries. The figure dropped to 12.4 percent for part-visual and part-instrument bombing, and from there to 5.4 percent for blind bombing with H2X. Bomber Command crews placed 15.8 percent of their bombs on target using night precision techniques. Given the navigational instruments of the day, and considering the long distances to their targets and the requirement for Pathfinder Force aircraft to mark them in overcast conditions, this was an incredible degree of accuracy, the effects of which were multiplied by the superior destructive

¹⁹ Ibid.

capacities of British bombs. Since individual Bomber Command raids delivered between five and ten times more bomb weight on their targets than did USAAF attacks, Bufton's and Maxwell's urgent calls for Harris to allow his heavies to fly night precision raids were entirely appropriate, as was Portal's polite but firm order to Harris to proceed with them. Finally, the short days and bad weather of fall and winter 1944-45 meant that only Bomber Command aircraft, flying night precision raids, could destroy the last functioning Bergius plants in central and eastern Germany.²⁰

The accuracy figures just noted, though good for the time, were determined by counting the number of bombs falling within the grounds of each installation. Using this methodology, BDA experts determined that 12.6 percent of all Allied bombs dropped on oil targets hit within the plant fences. However, only 3.3 percent hit buildings, equipment, and other structures that could be damaged. Of these, between 24 and 31 percent failed to detonate. Tail fins often detached, making the bombs land flat ("pancake"), in which case the fuses were not tripped. In other cases the arming wires were found intact, and in still others the fuses had broken off.²¹

During the oil offensive, the average weight of the 508,512 high-explosive bombs dropped on oil targets was 480 lbs., with the American average at 388 lbs. and the British at 660 lbs. This major disparity in average individual bomb weight was due to continued American employment of 250-lb. and even 100-lb. general-purpose bombs during the first four months of the offensive, while the British used nothing smaller than 500-lb. bombs and more often used 1,000-lb. munitions and a smaller number of their extremely

²⁰ USSBS Oil Division, *Oil Division Final Report*, 2nd Ed., January 1947, 1-2, 4 and Figure 2, 86-87.

²¹ *Ibid.*, 4, 6, and Figure 7.

destructive 4,000-lb. weapons. Based on these findings, the USSBS Oil Division declared that “under bombing conditions which permit sighting on a specific aiming point and with reasonable bombing accuracy, heavy bombs (2,000 to 4,000 lb., instantaneously fused) are several times as effective per ton as the lightweight bombs (500 lb. or less) used principally against German oil targets.”²² Neither the Americans nor the British used incendiaries against oil plants until late 1944, and even then the Americans tended to drop them from the first aircraft over a given target rather than the last. Had they dropped them towards the end of each raid, they would have caused much greater fire damage.²³ The British, however, placed their incendiaries on following aircraft and thus did much greater damage. Albert Speer noted that “The best and most effective attacks were the last raids by the R.A.F. on Pölitz and Brück, which, thanks to the mixed bomb loads had excellent effects.”²⁴ The British method for employing mixed bomb loads was based on recommendations of the ground survey team that visited Ploesti after its capture by the Russians. They noted that mixed high-explosive and incendiary bomb loads were highly effective as long as enough oil and fuel had spilled from storage tanks and plant equipment by the time the incendiaries arrived. British raids on Bergius plants in late 1944 and early 1945 employed this tactic with devastating effect, in the process providing another example of the iterative learning process facilitated by superb BDA.

Given the Allies’ determination to destroy Germany’s oil industry, and with it the German military’s ability to fight a war of maneuver on three fronts, they managed to put

²² Ibid., 6.

²³ Ibid., 6-7, 128-129.

²⁴ AIR 20/8779, Control Commission for Germany, Field Information Agency, “Examination of ex-Reichsminister Speer—Report 26,” 13 August 1945, 15. Based on Speer’s answers to a questionnaire entitled “The Effects of Allied Bombing of Germany.” Emphasis in original.

more than enough bombs on their targets. The results were catastrophic for German production of aviation fuel, which averaged 170,000 tons per month until April 1944. In June it was 52,000 tons, in December 26,000 tons, and in March 1945 zero tons. The figures were nearly as grim for gasoline production: 121,000 tons up to April 1944, 75,000 tons in June, 50,000 tons in December, and 39,000 tons in March 1945. As a result of the oil offensive and major combat operations on three fronts, total stocks of all finished POL products dropped from 1,372,000 tons in April 1944 to 436,000 tons at the end of 1944. Gasoline comprised only 120,000 tons of this total and there was almost no aviation fuel to be had anywhere.²⁵ The importance of these drastically reduced production figures becomes even clearer when we consider Albert Speer's comment that "The possible German production in 1944, excluding Roumania, would have been adequate to cover requirements. It would have guaranteed the mobility of the Army and Air Force."²⁶ Combined with the 245,400 tons of lost production from Rumania, total loss of fuel production from 1 April 1944 to 31 December 1944 was 2,489,000 tons, a quantity which, said Speer, *would have met all German requirements for 1944.*

The USSBS Oil Division's final report also emphasized that

The interpretation from aerial photographs of damage done and the estimates of its effect on production were on the whole remarkably accurate. The predicted dates for resumed operations in plants which had been closed by raid damage usually fell within a few days of the actual date as indicated by plant records. These predictions provided an excellent calendar for bombing operations.²⁷

²⁵ Ibid., 25, Table 12 and 28, Figure 23.

²⁶ AIR 20/8780, Control Commission for Germany (BZ), Field Information Agency, Report No. 62, Interrogation of Albert Speer on "The Effects of Aerial Warfare and Allied Successes on German War Production" (interviewed on 6 September 1945), 8 November 1945, 30.

²⁷ Ibid., 131-132.

The report also noted that ACIU photointerpreters estimated damage to plants, reductions in output, and probable dates when damaged plants would resume production with a remarkable degree of accuracy. Based on the results of previous raids, they also made recommendations for bomb sizes and types for attacks on the various targets. They sent these reports to a large number of air intelligence organizations and, most importantly, to the CSTC Working Committee (Oil), which met every Monday in London to examine all the available BDA reports and draft a priority oil targets list, which went to the CSTC for discussion and modification as deemed necessary. The CSTC also used ACIU, RE8, and SHAEF G-2 damage assessments. Although these estimates were on the whole quite good, they overestimated monthly production at Bergius plants by about 23 percent, output at Fischer-Tropsch plants by as much as 200 percent (although this was the exception), and fuel production at crude oil refineries by perhaps 30 percent. This resulted, during the middle portions of the oil campaign, in more missions than required against Fischer-Tropsch plants, an error corrected by February 1945.²⁸

These were reasonable criticisms, but the USSBS analysts somehow managed to overlook the fact that these estimates resulted in large measure from a standard practice in the intelligence business of providing “worst-case” estimates. In line with this approach, CSTC production estimates for current and future months assumed that *no additional damage* would be done to any oil targets, a point they emphasized in their weekly bulletins tracking the progress of the oil offensive, with the stated assessment that more damage would likely be done. And in fact the production figures changed in every weekly bulletin. The USSBS survey teams missed this and thus portrayed the CSTC

²⁸ Ibid.

estimates, themselves the product of ACIU, RE8, and MEW damage assessments, as being much less accurate than they really were. There were overestimates, especially regarding Fischer-Tropsch plants, but they were neither as great nor as pervasive as the USSBS report indicated.

What was absolutely clear by the end of the war, regardless of occasional inaccuracies in the damage assessments, was that Allied BDA experts played a leading role in the destruction of Germany's oil industry, not in the same heroic fashion as the men who flew the missions, but by giving the targets committees (first the JOTC and later the CSTC) all the intelligence required to make the best possible target recommendations to Bottomley and Spaatz, who relied on these recommendations to keep their bomber crews focused on the most lucrative oil targets.

As for the effectiveness of transportation attacks, any criticisms we might make of them must take into account an issue of fundamental importance: Until February 1945, and again from late March to VE Day, they were focused first and foremost on assisting the Allied ground advance. In fact, CSTC minutes from an 8 November 1944 meeting noted that transportation attacks against the Reich from September to the start of the Ardennes Offensive were designed to do just this. They were also, significantly, designed to provide the greatest possible assistance to Allied operations on the Italian Front and the Red Army's advance across southern Russia and the Balkans, and later through Upper Silesia and to the Oder River.²⁹ Third in importance after these two primary aims was exerting the greatest possible pressure on German war production by

²⁹ The air effort in the Balkans was significant and in effect comprised a "fourth transportation campaign" in addition to those against the Italian railroads, French and Belgian railroads and canals, and the Reich. It receives additional attention later in this chapter.

attacking railroads and inland waterways. By 10 February 1945 the CSTC had developed a detailed plan for attack by strategic and tactical air forces on German transportation assets leading to and from the Ruhr.³⁰ The plan was approved at the Air Commanders' Meeting on 18 February, due in large part to Tedder's efforts. This was inexcusably late, as Mierzejewski noted. However, in fairness to the CSTC and senior airmen, this delay was in part the result of two unforeseen developments: the diversion of heavy bombers to interdiction attacks during the Ardennes Offensive, and the subsequent effort against marshalling yards all across Germany to delay the movement of 6th SS Panzer Army and other units from the Western Front to the East.

It is significant that the majority of senior German officers and civilian officials interrogated after the war said that the destruction of the Third Reich's railroads and canals was the most important factor in Germany's defeat. Only Albert Speer and Hermann Göring thought the oil offensive was more important when pressed to make a choice.³¹ However, several senior officials, including *Generalfeldmarschall* Erhard Milch and Speer himself, recognized that making such a pronouncement was largely senseless in view of the degree to which the transportation and oil offensives were intertwined and synergistic. Milch observed that "The decisive moment was relatively

³⁰ AIR 40/1516, "Review of the Operations of the Working Committee (Communications), Combined Strategic Targets Committee, October, 1944 – May, 1945," 14 June 1945, 20-21.

³¹ It is significant that the Germans' military doctrine and plans, and indeed their very conception of war itself, was inextricably intertwined with and dependent upon the *Reichsbahn*. No other major military power relied so heavily on the railroad, and it therefore seems likely that most German senior officers had a predisposition towards ranking transportation attacks higher than oil attacks. The fact that Speer, who of all people might have been expected to take this approach but instead chose oil as the most vital target set, is particularly interesting, as is the fact that he mentioned the effects of oil attacks constantly in postwar interrogations. Göring's view is less surprising given that the Luftwaffe literally could not operate without aviation fuel. In the right operational and tactical conditions, the army could engage in static defensive operations and hold a line for weeks or even months without adequate gasoline, but the Luftwaffe could not operate at all without aviation fuel.

late; *it happened when you started large-scale attacks on our synthetic oil plants simultaneously with attacks on our communications.*"³² The most intelligent German leaders recognized that trying to make judgments about the efficacy of one of these two campaigns without reference to the other was simply misguided. The synergy between the two, appearing in a variety of important and often unlooked-for effects on the German war effort, proved decisive in undermining the Third Reich's military and economic power at the fighting fronts, in the factories and oil plants, and at all points in between.

Although we cannot know exactly how much these BDA experts' insights shortened the war and Allied casualty lists, it is perhaps enough to pose this counterfactual question: How much more difficult would it have been to defeat a German army and air force with adequate supplies of fuel, ammunition, and heavy weapons, able to mass and maneuver on a large scale, still very ideologically motivated, and fighting to keep Allied armies from entering the Reich? The Allies would have prevailed, but the battle would have been longer and the costs much greater.

12.3 The Forgotten Transportation Offensive: Air Attacks in the Balkans

The transportation offensive in France and Belgium, and the one against the Reich, were the most important of the war from the Anglo-American perspective. While both were planned and executed with the advance of Allied ground forces most firmly in mind, the latter was also designed to maximize the speed of the Red Army's advance, a point discussed in previous chapters. Spaatz and Bufton in particular championed bomber support to the Red Army in the planning and execution for every major bombing

³² Spaatz Box 134, CSDIC (UK), Interrogation Report CS/2126, entitled "Generalfeldmarschall a.D. Milch," 23 May 1945, 1. Emphasis added. Milch included German railroads and inland waterways when he referred to air attacks on "communications."

campaign from early 1944 to VE Day. This was clearest in Spaatz's efforts to gain Ike's approval for an oil offensive and in heavy attacks on crude-oil refineries and marshalling yards at Ploesti. When we recall that nearly all of the oil and fuel produced at Ploesti went to the Eastern Front, it becomes easier to perceive the degree to which the Red Army benefited from these attacks. What has remained almost entirely hidden in the historical record, however, is the extent to which senior airmen sought to undermine transportation infrastructures in the Balkans specifically to aid the Red Army's advance while hampering the movement of German forces. By April 1944 MAAF planners were already working, at Spaatz's behest, on a transportation plan to assist the Red Army.

Group Captain J. C. E. Luard, Chief of MAAF Intelligence, produced a paper in which he examined "the possibilities of aid to the Russians through attacks on the Balkan communication system by Italian based long range heavy bombers."³³ Luard made all the correct judgments about what would happen on the ground, and about how heavy bombers could best assist the Soviet advance. He began with an observation that the Russian capture of Cernauti had severed the main German supply lines to the southern portion of the Eastern Front. The result of this development was that it threw practically the entire burden of supplying German troops on the Hungarian and Rumanian rail systems, which were confined between the Carpathians on the north and the Danube on the south. In between, Luard observed, trains had to move through a series of bottlenecks, including a number of vital bridges and tunnels, before they emerged onto the relatively flat lands to the east. This also meant, by extension, that German troops

³³ Spaatz Box 17, Group Captain J. C. E. Luard, Chief of Intelligence Section, MAAF, "The Balkan Situation—Possibilities of Air Attack," 24 April 1944, 1.

along the southern portion of the front were almost entirely dependent upon Rumanian fuel for their mobility. Luard identified three key transportation bottlenecks: Bucharest, Brasov, and Ploesti (the latter was about halfway between the other two). The daily capacity of the two main rail lines leading through Ploesti was 33,000-36,000 tons per day. The Danube was no longer a feasible alternative due to Allied mining, which had made shipments on the river perilous.³⁴

Luard then estimated that German requirements along the southern portion of the Eastern Front were 12,000 tons per day. This yielded at most a 3:1 rail capacity-to-supplies ratio, compared to 10:1 in Italy, making the three Rumanian rail centers in question—and the tunnels and bridges in between—prime candidates for heavy-bomber attacks. (For instance, the Ploesti-Brasov section of this rail line passed through two passes in Transylvanian Alps. In this 30-mile stretch there were 13 bridges, five tunnels, and a number of cuttings passing in some places under soft rock walls. The entire stretch was extremely vulnerable to bomber attacks.) Luard believed concerted attacks on these targets would achieve four things: facilitate a more rapid Russian advance, undermine the governments of Germany's Balkan satellites and cause their defection to the Allied cause, interfere seriously with the German ability to withdraw into and through the Balkans, and act as the precursor to a follow-on bombing campaign designed specifically to hinder the escape of German units from Greece and southern Yugoslavia. "The main purpose," Luard concluded, "is not to attack transportation per se, or to destroy freight cars and

³⁴ Ibid., 2-3.

locomotives, but to reduce the rail capacity to the Eastern Front to the point where the enemy is no longer able to supply his troops opposing the Russian Army.”³⁵

The concerted heavy-bomber attacks that followed accomplished exactly what Luard had said they would, from denying the German army fuel and ammunition, to hindering the German retreat from the East and the Balkans, to causing the defection of the Balkan satellite states to the Russians, and finally to hindering the withdrawal of German troops from Greece and southern Yugoslavia. In the latter case, heavy attacks on marshalling yards and bridges in northern Greece and southern Yugoslavia slowed the German withdrawal and provided opportunities for Tito’s Partisans and the Red Army to attack and destroy a number of retreating German units.³⁶ This was another example of the pragmatic approach to heavy-bomber operations prevalent among Allied senior airmen.

12.4 Missed Opportunities: Ball Bearings and Power Plants

Albert Speer noted that there were two potentially decisive targets the Allies failed to attack with sufficient force to serious damage to the German war effort. As we have seen, USAAF attacks on ball-bearing production in 1943 did substantially greater damage than BDA experts recognized. Speer argued that the Allies could have had a decisive impact on ball bearings if all plants had been attacked simultaneously, if the attacks had been repeated three or four times at intervals of two weeks, and if reconstruction efforts had been hampered by further attacks as plants were ready to begin producing again.³⁷

³⁵ Ibid., 8.

³⁶ MS16, S3, B4, F2, Cable, HQ MAAF to AFHQ and USSTAF, “Priorities for bombing Effort in South-East Europe,” 5 September 1944.

³⁷ AIR 20/8779, Control Commission for Germany, Field Information Agency, “Examination of ex-Reichsminister Speer—Report 26,” 13 August 1945, 13. Based on Speer’s answers to a questionnaire entitled “The Effects of Allied Bombing of Germany.”

Speer also said that a concerted attack on the Reich's electrical power grid could have been even more decisive. Indeed, he said that such an attack, carried out in conjunction with a major effort against ball-bearing factories, would have had a catastrophic effect on armaments production. Speer concluded that the "Destruction of power stations is the most effective means of bringing the whole of industry and public life immediately to a standstill."³⁸ Electric power plants had a position of prominence in AWPD-1 and in the RAF's prewar "Western Air" (WA) war plans, but in both cases these insights were lost as staff officers planned bombing campaigns during the war.

12.5 Heavy Bombers in Direct Support of Armies: A Decisive Weapon

Under the proper conditions, heavy bombers played a vital role in facilitating the breakout and advance of Allied armies. This was nowhere clearer than in Normandy, where they literally blasted huge holes in the Germans' front lines during the July-August breakout. The BDA was not long in following, and like the damage assessments produced during the transportation offensive, it spurred an iterative learning process in which air intelligence personnel, senior Allied airmen, and heavy-bomber crews all applied lessons learned during the Normandy campaign to the transportation offensive against the Reich and to close air support during several major ground campaigns from the fall of 1944 to VE Day.

The devastating effects of heavy-bomber attacks against German troop concentrations during the breakout from Normandy became clear immediately, as Allied forces advanced through the bombed areas and the stunned German soldiers they captured related the effects of these attacks once they had recovered their hearing and

³⁸ Ibid. Emphasis in original.

their self-composure well enough to be interrogated. Even those who escaped the bombing spoke after the war of its devastating effects.

In the aftermath of heavy bomber attacks against the Panzer Lehr Division's positions near St. Vith on 25 July, General Bayerlein said the ground as far as he could see was a moonscape (*Mondlandschaft*), "all craters and death."³⁹ At least 70 percent of his personnel were out of action, either killed, wounded, dazed, or crazed. The 30-40 tanks he had on the front line were all knocked out, and the entire command post of his 902nd Regiment was annihilated, simply disappearing in the maelstrom brought on by the heavy bombers. Another day of heavy-bomber attacks followed on 26 July, succeeded immediately by fighter-bombers "relentlessly hounding and shooting at every living thing."⁴⁰ By 28 July Panzer Lehr had ceased to exist as a fighting division.

"Kampfgruppe Panzer Lehr," with less than 10 tanks and very little other heavy equipment, attempted to retreat in front of the American advance, hounded and attrited the entire distance by fighter-bombers. After the war, Bayerlein said he was "unable to decide" whether strategic or tactical airpower had a greater effect on his division. Unfortunately, the interrogator posed a poor question here and created a false conundrum for Bayerlein. The answer, in short, was that the two worked very effectively *in combination*, producing a synergy whose effects would have been largely absent had the Allies relied only on one type of airpower or another. The question also posed a false dilemma in that it was fixated on two categories—"tactical" and "strategic"—when the real issue was the level of effects and effectiveness achieved when heavy bombers, night

³⁹ MS16, S5, B12, F10, HQ 9th Air Force APWIU, "A Crack German Panzer Division and What Allied Air Power Did to It between D-Day and V-Day," 29 May 1945, 7.

⁴⁰ Ibid., 8.

bombers, and fighter-bombers worked together. Viewed in this fashion, the Allied air campaign in France produced tactical, operational, and military-strategic effects that resulted in high effectiveness when employed in conjunction with a superbly planned and executed Allied ground offensive, resulting in the breakout from Normandy.⁴¹

Obergruppenführer Josef "Sepp" Dietrich, commanding 1st SS Panzer Corps, made the same kinds of observations, noting that heavy bombers played an important role in undermining his defense of Caen with saturation attacks against his four divisions.⁴² Just how devastating their attacks were became clear once the British Bombing Analysis Unit, formed to conduct ground surveys in areas liberated by the Allied armies, produced a study on the effects of a heavy-bomber attack against a German tank unit and battalion headquarters bombed at Guillerville, near Caen. A total of 15 tanks, 20 other vehicles, and numerous horse-drawn wagons of the 21st Panzer Division, *Abteilung* 503, were dispersed in a 42-acre orchard when Bomber Command heavies dropped 2,480 tons of bombs (including 2,846 1,000-lb. and 4,219 500-lb. bombs) directly on the orchard in support of Operation Goodwood. The tank formation was blanketed by 145 bombs averaging 700 lb. in weight and producing craters from 15 to 45 feet in diameter. Several crews were killed in their tanks and many others outside their vehicles. Some 40,000 tons of debris (earth, rocks, and trees) were set in motion during the bomb strikes. Consequently, debris, ground shock, and blast waves destroyed all but two tanks and damaged all other vehicles in the area beyond repair. Every mechanized and motorized vehicle in the two units was destroyed. The two undamaged tanks were unable to leave

⁴¹ Ibid., 6-9.

⁴² RG243, E36, B185, 7th Army Interrogation of *Obergruppenführer* Josef "Sepp" Dietrich, Commander, 1SS Panzer Corps, 1944, 11 June 1945, 1-2.

the area due to heavy cratering and had to be abandoned. The fate of the horses is best left to the imagination. This study concluded that in wooded terrain, an average bomb density of 10 strikes per acre by 500-lb. and 1,000-lb. bombs was sufficient to immobilize tank and vehicle concentrations. The fact that Allied intelligence personnel never again identified tanks from this unit in ground operations stands as mute testimony to the fact that the unit was obliterated by this very accurate saturation bombing and never reestablished. Photographs taken by the ground survey team provided further evidence of the *Mondlandschaft* created by RAF bombers in this attack.⁴³

An AEAf BDA report produced in August noted that although the use of heavy bombers in a tactical role was new and could produce friendly casualties if not employed with great care, it was nonetheless clear that "where they have participated, land operations have been greatly facilitated. In several instances the help provided has been a decisive factor in the overall success achieved."⁴⁴ A USSTAF A-2 study published in February 1945, and based on POW interrogation reports, captured enemy documents, Operational Research Section studies, and photographic intelligence, said

The available evidence indicates clearly that Carpet Bombing has been notably successful in destroying the efficiency and initiative of the German soldier, both as an individual and as a member of the combat team. Massed heavy bomber attacks have been instrumental in providing the Ground Forces with the initial advantage essential to the successful exploitation of a break-through or the impetus to attack.⁴⁵

The study noted that the morale and physiological effects of bombing were severe even for well dug-in troops. Germans captured after carpet bombing at Caen could not be

⁴³ AIR 37/1263, B.A.U. Report No. 22, "Ground Survey of the Results of an Attack by Heavy Bombers on a German Tank Concentration," 11 January 1945, 1-7.

⁴⁴ AIR 37/759, AEAf, "Use of Heavy Bombers in a Tactical Role," 30 August 1944, 13.

⁴⁵ MS16, S5, B12, F14, HQ USSTAF A-2, "Intelligence Study on Effectiveness of Carpet Bombing," 21 February 1945, 1.

effectively interrogated for at least 24 hours because the attack had left them totally, if temporarily, deaf. Unit cohesion disappeared, but men often fought on as individuals or in very small groups if more than two hours elapsed between carpet bombing and the Allied advance. Most German prisoners said the psychological effects of heavy-bomber attacks were the most significant factor in reducing the effectiveness of enemy resistance. The loss of weapons was an even greater factor than personnel casualties in reducing resistance. In fact, personnel losses were usually between 5 and 10 percent, while vehicle and equipment losses were significantly higher—up to two-thirds of vehicles, artillery pieces, and other heavy equipment assigned to units attacked in this manner. Perhaps most important, however, was the fact that massed heavy-bomber attacks cut road and signal communications, creating insuperable command-and-control and re-supply problems for those soldiers still able to fight. The report closed by recommending that Allied ground attacks follow carpet bombing immediately, while German troops were demoralized.⁴⁶ These tactical uses of heavy bombers demonstrated their versatility as well as their ability to produce decisive effects at the tactical and operational as well as the military-strategic levels. The ability to provide detailed BDA for these missions, and indeed all BDA capabilities during the Second World War, grew from a number of crucial BDA developments during the Great War and the interwar period.

12.6 Deeper Continuity: Influences of World War I and the Interwar Period

Aside from demonstrating the versatility of heavy bombers, the wide range of target sets they engaged, from the enemy's fielded forces at the tactical level to transportation and oil targets at the military-strategic level, also made clear the vital role of air

⁴⁶ Ibid., 4-8.

intelligence in allowing senior airmen to discern the importance of these target sets, target and attack them with great effect, and then assess with a high degree of accuracy the effects and effectiveness of their bomber crews' efforts. This targeting-bombing-BDA feedback loop, which reached its apogee in 1944-45, rested on a variety of developments stretching back through the interwar period to the Great War. A brief recapitulation of BDA developments in these crucial periods is indispensable to understanding how BDA came to be so effective in World War II.

The most vital thing to bear in mind about the Great War is simply that a rudimentary but real BDA intellectual infrastructure had emerged by late 1917. As we discussed in Chapter 2, this development depended not only on the evolution of airframes capable of aerial bombardment, but even more fundamentally on the organizational innovations necessary for amassing, assessing, and acting on the ever-larger quantities of BDA photographs and other sources pouring into Air Ministry offices and the AEF's Air Staff in France by the summer of 1918. The emergence of the world's first modern air staffs provided the organizational foundations necessary for analyzing BDA data and providing actionable damage assessments quickly to both senior airmen and bombardment units in the field. An example of this dynamic was Lord Tiverton's ability to bring together officers in both the Operations and Intelligence Directorates at the Air Ministry as he worked with them to develop and promulgate his targeting plan for German nitrogen-fixation and other ammunition-production plants. Although Trenchard and Haig chose to ignore this plan and focus their bombing efforts on enemy airfields and railroad junctions close to the front, Tiverton's efforts nonetheless indicated that the ability to conduct both targeting and BDA functions had emerged by early 1918.

These rudimentary capabilities were themselves dependent on the emergence of new technologies, technicians, and techniques at all echelons. The most basic technologies included the aerial camera, which by 1918 was becoming quite sophisticated (with automatic film cameras replacing the older manual plate versions), stereoscopes, much better film, and purpose-built reconnaissance aircraft in which cameras could be permanently mounted and automatically operated. Of course, these new technologies required entirely new kinds of technicians and specialists to operate the equipment, develop and disseminate aerial photographs, and then analyze those photos along with all other available intelligence sources in order to produce damage assessments for specific targets and to make larger judgments about bombing's effectiveness. The two most important new specialists to emerge during the last year of the Great War were photointerpreters and combat intelligence officers, both of whom were at the center of the emerging BDA process as it was practiced in 1917-18. Indeed, along with staff officers such as Lord Tiverton, these BDA experts formed the *intellectual* component of the intellectual infrastructure emerging by 1918. They worked within the *infrastructure* component, which, as we have seen, included the air staffs in both the British and American air arms as well as the photointerpretation and combat intelligence sections established at bombardment units.

Although Trenchard's decision to employ his bombers against tactical targets rather than the military-strategic targets selected by Lord Tiverton and endorsed by Major General Sykes, the Chief of the Air Staff, the process of collecting BDA-related intelligence, moving it quickly to the proper echelons for analysis, and turning it into damage assessments for use in planning and executing further raids, was important in its

own right. We should recall that a number of the junior officers employed in this endeavor, including V. C. Laws, H. Hamshaw Thomas, Harry Stringer, Sidney Cotton, George Goddard, and George McDonald (the USSTAF A-2), continued to push the constituent parts of the intellectual infrastructure forward in the interwar period and during World War II. Once we do so, the importance of the Great War as the foundational event in the development of mature BDA capabilities during the Second World War becomes clear.

Indeed, the interwar period, often seen as a period of fiscal austerity and visceral aversion to war, proved to be a fertile field for the continued development of key elements of the intellectual infrastructure. Although the organizational component withered with the disestablishment of the AEF's Air Staff and the dramatic contraction in the size of the Air Ministry, the technologies and techniques associated with aerial photography made huge strides. George Goddard played the leading role in this process for the Air Corps, as did V. C. Laws for the RAF. Doctrinal developments in the U.S. Army Air Corps also accelerated as officers at the Air Corps Tactical School promulgated and refined their high-altitude, precision, daylight bombardment doctrine during the 1930s. One of the greatest ironies in this process, however, is the fact that the officers responsible for developing American bombing doctrine and procuring the B-17 heavy bomber ignored the requirement for a "precision BDA" capability to maximize the effectiveness of aerial bombardment. As we have seen, the exact opposite problem occurred in the RAF: although no heavy bomber or detailed bombing doctrine emerged during the interwar period, the first signs of a resurgent BDA intellectual infrastructure were evident when the Second World War began. These developments were spurred by

the rise of Nazi Germany after 1932 and included organizational innovations such as the Bombing Committee, the Bombing Development Unit, and the Joint Intelligence Committee of the Chiefs of Staff. Yet they had their genesis in the 1920s and early 1930s with the formation of the Advisory Committee on Trade Questions in Time of War (ATB), its Industrial Intelligence Centre (IIC), and the Industrial Intelligence in Foreign Countries Sub-Committee (FCI), all of which were subsumed by the Ministry of Economic Warfare once the Second World War began. The Air Ministry also developed effective targeting capabilities in A.I.3.(c) and a small BDA office in A.I.3.(e). Finally, PRU1 and the CIU assumed the BDA function in superb fashion, building on the work of their predecessors: Sidney Cotton's SIS Flight and the Aircraft Operating Company.

Given this British head start in the development of BDA capabilities, and the lack of American interest and effort in this arena prior to the spring of 1941, the British became BDA masters and the Americans their apprentices. Fortunately, the British proved exceptionally pragmatic and gracious as they integrated American photointerpreters and other air intelligence specialists into their intellectual infrastructure, made their photoreconnaissance aircraft and BDA experts available to produce damage assessments for USAAF raids, gave their allies full access to BDA and targeting materials, and, most importantly, treated them as equals in the decision-making processes surrounding the maturation of the BDA intellectual infrastructure. The Americans, for their part, recognized that they were the primary beneficiaries in this process, and they also made a major and successful effort to pull their own weight by 1944.

The upshot of these developments, as we have seen, was a BDA intellectual infrastructure that reached adolescence by 1942 and maturity by 1944. This unique

capability allowed the Allies to determine with great precision what their bombing raids were doing to the German war effort. There were, of course, exceptions to this rule. The most glaring was RAF city bombing, for which BDA could provide quantitative measures of damage but few qualitative judgments. Ironically, BDA experts recognized fairly early in the process that city bombing spurred the dispersal of German industries but missed the degree to which this would make the German war economy vulnerable to disruption by transportation attacks. Even more ironic is the fact that despite clear evidence in postwar interrogations, the USSBS simply ignored this crucial contribution of city bombing to Allied victory. The only other clear failure in the BDA process was the slow recognition among air intelligence officers of the imminent collapse of Germany's transportation networks and, by extension, her war economy, in the late fall of 1944. They did collapse, but not until the late winter of 1944-45, and there is evidence to indicate that the Allies could have brought on a collapse at least two months earlier had their targeting and BDA efforts been more effective. Mierzejewski's arguments on this score are compelling.

Aside from these shortcomings, the intellectual infrastructure worked exceptionally well and played a central role in the destruction of French and Belgian railroads and canals in support of Overlord, and of Germany's oil industry and transportation networks. Its key elements included an organizational structure within which targeting and BDA agencies routinely exchanged information and shared expertise; highly trained BDA experts; and superb reconnaissance aircraft, cameras, and film. Most important, however, were the experience and judgment that grew out of a long war in which BDA experts engaged in an iterative learning process, applying lessons learned from recent campaigns

to future ones. The ground survey teams that visited the Ploesti refineries, the fuel depot and POL production facility at Gennevilliers, the marshalling yard at Trappes, and dozens of other targets, thus played a vital role in maximizing the effects and effectiveness of the Allied bombing effort. So, too, did RAF and USAAF Operational Research Sections, which produced very detailed MEA for every sort of bombing raid, from those using visual techniques to those employing Gee-H and H2X. These agencies helped senior airmen and bomber crews to determine *what* to bomb, and *how* and with *which munitions* to bomb various targets. The result was a BDA capability not equaled before or since.

Indeed, the decisive contribution of aerial bombardment to the Allied war effort, so clear in World War II, would be much less in evidence in later wars, not just because the “limited” wars of the Cold War period did not offer the same kinds of target sets and opportunities for decisive aerial bombardment, but also because the intellectual infrastructure so laboriously constructed for the BDA effort withered quickly after the end of the war and has never since reappeared. Consequently, the targeting-bombing-BDA feedback loop, and hence the employment of aerial bombardment, has tended to be less effective since the end of the Second World War.⁴⁷

⁴⁷ The three most recent campaigns in which airpower has played major roles—Desert Storm in Iraq, Operation Enduring Freedom in Afghanistan, and Operation Iraqi Freedom in Iraq—are partial exceptions to this rule.

CHAPTER 13

BDA FROM WORLD WAR II TO THE TWENTY-FIRST CENTURY: OUTMODED FUNCTION OR INDISPENSABLE CAPABILITY?

Assessments of military effectiveness cannot, therefore, be reduced to the amounts of physical damage or destruction inflicted on targets, the quantities of military equipment damaged or destroyed, or even to the numbers of combatants directly wounded or killed. Instead, issues of operational-strategic effectiveness will also necessarily involve human plans, intentions, psychology, political ends, and other hard-to-quantify factors and considerations.¹

- Gulf War Air Power Survey, Volume II, Part II, 28

13.1 BDA since World War II: Fewer Capabilities, More Frustrations

The Allied BDA effort during World War II reached a degree of efficiency and effectiveness never equaled in any of the armed conflicts that have followed. The intellectual infrastructure built up at such great cost during the war withered away until only a shadow remained. This downward spiral in BDA capabilities became evident in two important ways during the Cold War. The first was a steady move away from photoreconnaissance aircraft to satellites, which were generally able to deliver high-resolution pictures but only of objects that fell within the “track” described by their orbit. In fact, satellites, which could gather imagery from above denied airspace, proved ideal photoreconnaissance and signals intelligence platforms for a Cold War rivalry between the Superpowers in which stability and transparency were of the utmost importance. Unfortunately, reconnaissance aircraft became scarcer and scarcer even though American

¹ *Gulf War Air Power Survey*, Volume II, Part II, “Effects and Effectiveness” (Washington D.C.: U.S. Government Printing Office, 1993), 28.

involvement in conventional armed conflicts continued. The result was an increasingly severe shortage of these high-value assets in every war from Korea to Operation Iraqi Freedom, although there have been some promising signs of a resurgence in the latter case. In a world no longer under the stabilizing influence of Superpower rivalry, a shortage of such air-breathing reconnaissance assets is a serious problem for targeting, BDA, MEA, and a number of other crucial intelligence functions such as indications and warning, enemy deployments and troop dispositions, and treaty compliance verification.

Another problematic development has to do with the growing number of American military officers who are now declaring BDA in any form outmoded and no longer of any value in today's fast-paced and dynamic military conflicts. These critics argue not only that the tools and techniques of BDA are outmoded and cannot possibly keep up with information-age war, but also that they are inherently weak instruments for gauging the effects of air operations.² They are mistaken on both counts. The tools and techniques are getting better every day, and it is now more important than ever to gauge, both rapidly

² See "BDA Fades Away," *Air Force Magazine*, August 2004, 9-10. General T. Michael Moseley, Vice Chief of Staff of the Air Force, stated here that BDA as it was formerly practiced no longer makes sense because the Air Force is focused on achieving certain effects rather than certain levels of destruction. He continued by labeling traditional BDA "almost a civil engineering function," noting that the real question to be asked is "Did we create the effect we were looking for?" Finally, he asserted that the goal is to automate as much of the BDA process as possible in order to create a machine-to-machine interaction in which a database "maintains custody" of all targets, noting automatically the numbers and kinds of munitions employed against them, and whether or not the targets are still active. Once destroyed, he said, the targets would disappear from the master target list. Most interesting is his closing thought about this process of determining whether or not a target has been destroyed, in which he noted that humans should not have to make *subjective judgments* about such matters (emphasis added). By extension, then, are we to assume that humans should no longer bother to make subjective judgments about the overall *effectiveness* of an air campaign; in other words, about the degree to which bombing is *effective* not just in destroying targets, but in supporting our military and grand strategies? Automation is laudable as long as it does not become an end in itself, but it appears perilously close to doing so in this vision of future air warfare. It is also worth noting that BDA experts and senior air commanders during the Second World War simply assumed that their job was to produce the greatest possible effects in their bombing raids. However, they also saw that stopping there, with the question of effects, was not sufficient. They recognized that effects had to be linked to the most important aid to analysis and judgment for BDA: effectiveness.

and accurately, the effects of air (and space) operations. The most serious failure of this emerging “anti-BDA” school is the tendency to focus on accuracy and effects while ignoring the much more important question of *effectiveness*. The Joint Direct Attack Munition, with its GPS guidance system, will hit and destroy its targets over 95 percent of the time, but knowing this helps us not at all with determining how or even if all these smoking craters contribute to making the air effort and, by extension, the larger military-strategic and grand-strategic efforts, as *effective* as possible. In other words, it would be quite easy to destroy a vast range of targets and not in any way bring us any closer to victory. The Rolling Thunder air campaign against North Vietnam was a clear example of this problem. A crucial issue at the heart of this ongoing debate is the fact, entirely overlooked by critics, that BDA is *not* limited to the assessment of physical effects, but can—indeed must—include assessments of the enemy’s morale, motivation, and intent.

A similar problem was at work during the 1999 NATO air campaign to stop Serb ethnic cleansing in Kosovo. Although Serbian President Slobodan Milosevic capitulated, he did so much later than NATO political and military leaders anticipated, and it appears likely that the threat of a ground invasion rather than the damage caused by NATO air attacks on Serbian ground forces in Kosovo and the economic infrastructure in Belgrade was the most important factor in his decision to give in. The dismal BDA record in Kosovo featured exaggerated claims of Serbian heavy equipment destroyed, too few photoreconnaissance platforms, and the problems associated with collecting BDA in an environment where poor weather, mountainous and wooded terrain, and the enemy’s excellent camouflage, concealment, and deception operations caused NATO jets to bomb a large number of dummy tank and artillery targets. Exaggerated claims of damage to

Serbian forces in Kosovo were made to look foolish by news footage of Serbian columns withdrawing in good order and discipline, their morale evidently intact, a far cry from the repeat of attacks on Bayerlein's Panzer Lehr Division that we had been led to expect. Ironically, media coverage often appeared to be the only decent BDA reporting NATO forces received. Even more important was the glaring lack of effective targeting prior to the air campaign, a problem caused in large measure by the failure of NATO leaders to devise a realistic and effective military strategy for compelling Milosevic to back down. Even the best BDA capabilities would have failed in such a case.³ Most glaring of all, however, was the entirely *ad hoc* nature of the BDA intellectual infrastructure, such as it was, which was cobbled together as the air campaign began. The lack of a *standing* intellectual infrastructure was a serious problem then and remains so now.

This necessity to measure the effectiveness of air campaigns and the military strategies they support will require substantial improvements in current BDA capabilities, which must be reorganized and restructured to deal with the much more complex armed conflicts of the early twenty-first century, most of which feature unconventional enemies, target sets difficult to discern, and open-ended campaigns against terrorists, narcotraffickers, and other "new-age" enemies. Improved BDA capabilities and methodologies must play a major role in determining the efficacy of our country's aerospace operations and the ways in which this effectiveness translates into tangible advantages on the battlefield and at the negotiating table. Without effective BDA, we will simply have to guess at these things, and guessing is never a good option.

³ For a good assessment of the Kosovo air campaign and problems associated with BDA, see Benjamin S. Lambeth, *The Transformation of American Air Power* (Ithaca, NY: Cornell University Press, 2000), 186, 194-197, 232. See also Dana Priest, "The Commanders' War: The Plan to Invade Kosovo, A Decisive Battle that Never Was," *The Washington Post*, 19 September 1999.

The most obvious error in current criticisms of BDA—namely, that it became a glorified civil engineering function during World War II and has since continued to be so—confuses techniques with the underlying rationale for having a BDA capability in the first place. The bombing campaign against Germany focused on industrial target sets that lent themselves to statistical analysis and quantitative assessments. The same is not likely to be true, or will at least be less so, in future wars, but this does not mean BDA will be unimportant. It simply means that the intellectual infrastructure will look different as will the techniques and measures of merit employed to produce damage assessments. Nonetheless, the BDA effort during World War II was focused first and foremost—and by 1944 very effectively—on gauging the accuracy, effects, and effectiveness of Allied bombing. The same could be said, although to a lesser degree, of the BDA effort during the Korean War.⁴ Yet when the Air Force decided after the Korean War that the conflict there had been an anomaly, and that nothing remotely like it was ever likely to occur again, the drift from a focus on BDA for conventional operations began to give way, with increasing acceleration, to one focused on BDA for nuclear ones.

It was here where BDA began to acquire some of the sterility and irrelevance noted by current critics. Even so, their criticisms overlook the fact that there was always a need for a robust conventional BDA capability whether or not any senior military leaders

⁴ The best single work on American bombing operations during the Korean War is Conrad C. Crane's *American Airpower Strategy in Korea 1950-1953* (Lawrence, KS: University Press of Kansas, 2000). Crane notes the successes and the frustrations inherent in trying to use airpower—the most modern implement of war—against enemies whose economic infrastructures were small, who had outside aid and support, and whose armies employed superb camouflage, concealment, and deception techniques, including a policy of making troop movements only at night. In this sense, the Korean War was something of a hybrid air campaign that employed many of the same BDA tools as the ones used in the Second World War, but also one in which air intelligence personnel and operational commanders were almost constantly frustrated at their inability to find vital target sets or enemy vulnerabilities, such as oil and transportation in the case of the war against Germany, which they could attack to produce decisive results.

happened to recognize this, and the Vietnam War brought this point home with a good deal of force and no little amount of discomfort. In fact, the BDA effort during that conflict brought to the fore all the worst attributes of BDA policy and techniques as they developed under the lead of the Strategic Air Command and the nuclear imperative: the “green door” syndrome—the reference here was to the green-colored vault doors that guarded access to the most highly classified material—that literally built a wall between air intelligence and operations personnel; an unwillingness among unified, specified, and Service commands to share BDA reports; an increasingly severe shortage of reconnaissance aircraft as satellites increasingly replaced them; and a “bean-counting” mentality that sapped the larger effort and often reduced BDA to the civil engineering function it is now accused of having been throughout its existence.⁵

The ways in which the theater military commands that fight our wars interact with the Service intelligence organizations that provide them with intelligence personnel and

⁵ In *The 11 Days of Christmas: America's Last Vietnam Battle* (San Francisco, CA: Encounter Books, 2002), 68 and 241-242, Marshall L. Michel III provides a brief but useful summary of the various BDA and air intelligence problems during the Linebacker II campaign, including inadequate photoreconnaissance assets, both in terms of numbers available and capabilities, and major inefficiencies involved in making SAC the responsible command for carrying out the raids and therefore doing the targeting and BDA work, including the “green door” syndrome. The results, he said, were very inaccurate bombing (a circular error probable of 2,700 feet rather than the 800 feet predicted by SAC planners before the operation) and too few reconnaissance assets. In fact, Michel noted that “Throughout Linebacker II, the lack of bomb-damage assessment (BDA) photographs was a significant problem, and was to give a foreshadowing of problems later in the Gulf War and the conflict over Kosovo.” See pages 222-223 and 240-241. Ironically, and in another foreshadowing of more recent BDA problems, bad weather made the few manned reconnaissance aircraft largely incapable, while the relatively primitive (compared to today's UAVs) AQM-34L drones collected the vast majority of useful BDA photographs for Linebacker II, most of them collected from altitudes as low as 500 feet and below the nearly continuous cloud cover that hampered collection efforts by manned reconnaissance aircraft. Michel concluded with a powerful reminder: “Had the aim of Linebacker II been a military one, the lack of bomb-damage photographs would have had a major impact on the operation. Without photographs, bomb damage had to be estimated using SAC's predictions, but the first bomb-damage photographs made it clear that the damage to the targets was much less than SAC had claimed. Fortunately target damage was not the issue; Linebacker II was a political campaign that used physical damage to send a message. The BDA photograph problem was disconcerting but not critical, so it went uncorrected only to come back to haunt the U.S. forces in the Persian Gulf War, where lack of BDA photographs became a major issue.” See pages 241-242.

equipment are in many ways just as dysfunctional.⁶ Theater commanders want their own in-house BDA capability, and they want outside intelligence organizations (from the Joint Staff and the Air Staff at the Pentagon, among others) to assist only if and when their theater intelligence chief advises them to call for such assistance. In addition, targeting and BDA organizations in the various theaters tend to be small and *ad hoc* affairs, cobbled together only as required by necessity. The Joint Staff and Air Staff have their own targeting functions, but neither one appears to pay enough attention to BDA—in other words, to developing and maintaining a robust and *standing* capability to make reasoned and accurate judgments about the effects and effectiveness of air operations. In fact, the Air Force did away with targeting specialists in the mid-1990s (and therefore by extension with the only people qualified to serve as both targeting and BDA experts), instead asserting that intelligence officers should be generalists who can pick up the skills required for targeting and BDA on an *ad hoc* basis once assigned to support a given air operation. This on-the-job-training approach to targeting and BDA flies in the face of everything we know about these crucial functions, namely, that the skills required to practice them cannot be acquired overnight, that their form and content change modestly or substantially depending on the nature of the conflict at hand, and that they are in the most basic sense about judging the effects and effectiveness of military operations (or civil-military operations in the case of today's war on terrorism), a skill that has become more important and complex in the years since World War II. Instead of recognizing this

⁶ Theater commands (also referred to as unified commands) are America's combatant commands. In other words, their commanders have authority to plan and execute combat operations with the forces at their disposal. The most prominent theater commands at this point are European Command, Pacific Command, Central Command, Southern Command, and Special Operations Command. This combatant command structure was created as part of the Goldwater-Nichols Act of 1986.

and restructuring air intelligence to deal with it, our Air Force, Navy, and other Services seem content to let both the content and the conception of BDA simply fade away, to be replaced with a set of skills and techniques not yet even defined or clearly understood.

13.2 Effects-Based Operations: Not a New Development

The grand irony in this post-World War II BDA picture is the very fact that a number of military officers are now talking about effects-based operations as if they are entirely new to warfare.⁷ The reality, however, is that air intelligence personnel during World War II understood effects-based operations exceptionally well, and they added another component often lost in today's BDA arguments, namely, that we must not stop with assessing effects; we must go a step further and consider the overall *effectiveness* of our air attacks, when viewed in conjunction with land and naval operations, in helping us to achieve our objectives. Phillip Meilinger, one of the most impressive and prolific airpower historians, has addressed this issue in some detail, arguing that the concept of effects-based operations was not foreign to the air intelligence personnel and operational commanders of World War II. "Airmen," he said, "have always hoped to conduct EBO [effects-based operations], although they did not use that term."⁸ So far, so good.

However, Meilinger errs in his next statement that, "During most of World War II, the analytical, cognitive, and intelligence tools needed to determine the effectiveness of

⁷ See "BDA Fades Away," *Air Force Magazine*, August 2004, 9-10. The best concise definition of effects-based operations is perhaps the one in Paul K. Davis, *Effects-Based Operations: A Grand Challenge for the Analytical Community* (Santa Monica, CA: Rand Corporation, 2001), 7: "Effects-based operations are operations conceived and planned in a systems framework that considers the full range of direct, indirect, and cascading effects, which may—with different degrees of probability—be achieved by the application of military, diplomatic, psychological, and economic instruments." In this definition, the "systems framework" refers to target systems, which in their simpler guise during the Second World War were called "target sets." In Chapters 9-11, we saw several examples of cascading effects created by the transportation and oil offensives and their effects on the German war effort.

⁸ Phillip S. Meilinger, "The Origins of Effects-Based Operations," *Joint Force Quarterly*, 35 (Summer 2003), 1.

air operations were lacking on the strategic level...As a consequence, airmen...counted things, substituting quantification for evaluation.”⁹ While it is true that air intelligence personnel attempted to quantify the results of heavy-bomber operations, they did so not as an end in itself, but as a means for gauging their effectiveness in supporting Allied strategy. This was clearly the case with the oil offensive. Intelligence personnel had known before the war that the German oil position was vulnerable, but senior airmen lacked the bombers and air superiority necessary to go after these targets until May 1944. Once bombers did go after them in a concerted fashion, BDA experts highlighted the immediate and disastrous effects on Luftwaffe and German army operations. These oil attacks also interacted with raids on French and Belgian railroads and canals to create a doubly disastrous situation for German armies in which gasoline, even if available at fuel depots or the now far-distant railheads, often could not be found and brought up in sufficient quantities to allow for anything other than static, defensive operations. The raids were even more cataclysmic for the Luftwaffe, which experienced severe fuel shortages within a month of the attacks—shortages that led to a near-complete paralysis of air operations from summer 1944 to VE Day. The key thing to keep in mind here is that BDA and targeting organizations, including the JOTC and its successor, the CSTC, recognized the dramatic and rapid strategic, operational, and tactical effects of the oil offensive. Therefore, they kept senior airmen focused on the overall effectiveness of the oil offensive and its disastrous impact on German tactical mobility and combat power.¹⁰

⁹ Ibid.

¹⁰ The senior Allied airmen listened, as did General Dwight Eisenhower, the Supreme Allied Commander. The utterly tenacious focus on the oil offensive can perhaps best be summed up in a comment by the collective CSTC membership, in which they emphasized that “It was universally agreed that we should

Those who dismiss BDA as a glorified civil engineering function confuse its *tools* with its larger *purpose*. In fact, the BDA tools and processes used in World War II were appropriate given the industrial nature of the targets attacked and their relationship to the German war effort. Those same tools and techniques were clearly less efficacious when employed to determine the effects and effectiveness of air operations in Korea, Vietnam, Iraq, and the Balkans. Be that as it may, we still require a means for judging the effects and effectiveness of air operations, and that is what the related disciplines of BDA and Munitions Effectiveness Assessment (MEA)—now bundled together under the rubric of combat assessment (CA)—must provide. The importance of BDA remains the same; only the tools, techniques, and target sets change. We still need to know what we are doing to our adversary, and how those effects increase the effectiveness of our war effort. Scrapping the concepts associated with BDA will not help us do that. To the contrary, it would have a deleterious effect on a BDA capability that is already small and ineffective.

13.3 World War II and “Approximate Precedents” for 21st Century BDA¹¹

A USSTAF history produced after the end of the war in Europe had this to say about the role of USSTAF A-2, and by extension Allied air intelligence, in the Second World War: “Thus the mission of the Directorate of Intelligence was to serve as the eyes of the Strategic Air Forces in Europe; to seek out the enemy’s weaknesses and strengths and to

pursue oil to the last drop.” (AIR 2/8011, “Combined Strategic Targets Committee, Minutes of the 23rd Meeting, Held in Air Ministry, Whitehall, on Wednesday, 21st March, 1945,” 25 March 1945, 8).

¹¹ In *The Rules of the Game: Jutland and British Naval Command* (Annapolis, MD: Naval Institute Press, 1996), Andrew Gordon engaged in an outstanding discussion of the “syndromes” affecting British naval commanders before and during World War I, and the ways in which these aspects of naval culture influenced how they fought at Jutland. Part and parcel of this discussion was an effort to draw “approximate precedents” from the British experience at Jutland. These were not firm lessons, which Gordon and most other historians hesitate to apply, whole cloth, from one war to another, especially when those wars were separated by many years and involved military organizations employing very different technologies and organizational structures than those now in existence. This discussion of “approximate precedents” for BDA thus takes its lead from Gordon’s pioneering effort.

guide the striking forces through his defenses to his most vulnerable spots.”¹² Of course, this task fell largely to Allied targeteers. The BDA experts working within the Allied intellectual infrastructure then had to determine what bombing was doing to the German war effort, both in terms of specific effects and aggregate effectiveness. This was the most important service BDA experts provided during the course of the war: They gave senior airmen a very clear understanding of the damage their bombers were doing to the Third Reich’s war machine and its supporting industries.

There are, of course, many differences between BDA as it was practiced during the Second World War and as it is—or should be—practiced today. It is, however, no less important in the early 21st century than it was in the middle of the 20th. The differences are significant and can be dealt with quickly. Clearly, there are very few scenarios today in which a large-scale bombing campaign against a major adversary’s economic and military infrastructures might take place. The most likely exception to this rule is North Korea. Very few other potential adversaries would risk a conventional war with the United States, and it is very unlikely that North Korea would do so either. American aerial munitions are now so accurate and deadly that at the tactical and operational levels of war they are virtually guaranteed to destroy any heavy equipment or military installation they strike. However, the Serbian camouflage, concealment, and deception (CC&D) techniques, bad weather, and forested terrain that drove air planners and aircrews to distraction during Operation Allied Force should also remind us that we can waste a large number of weapons destroying decoy targets and, in the process, doing

¹² Spaatz Box 290, USSTAF A-2, “History of Directorate of Intelligence, United States Strategic Air Forces in Europe, January 1944 – May 1945,” 8 September 1945, 1.

nothing to further our cause. Indeed, in such a case it is altogether possible that the *attacker* will be more demoralized than the defender. Rolling Thunder was another case in point. The problem here is simple: We may now be able to destroy virtually everything we target, but we might very well target the wrong things, particularly if our targeteers lack proper training and choose the wrong target sets to engage, and we may not draw the proper conclusions about the effects and effectiveness of our air campaigns. And this is where the first and most enduring lesson of the Second World War comes into play. Put simply, *BDA still matters, and it matters a great deal.*

In air campaigns (and now *aerospace* campaigns), effectiveness will almost always depend on how well air intelligence personnel discern, target, and then assess damage to an enemy's key target sets. These are not likely to be as easy to determine as were the Germans' vital target sets—oil, transportation, and electrical power (and the Allies failed to engage the latter)—unless the issue is simply one of destroying an adversary's fielded forces. This airpower can do very effectively, *in the right kinds of terrain and weather and in the absence of an effective adversary CC&D capability*, without the need for a major BDA effort. With kill rates of nearly 100 percent, the Joint Direct Attack Munition and other advanced weapons simply will not miss. But as we have discussed, these kinds of old-style pitched battles are the least likely scenarios at this point. Much more likely are open-ended campaigns against terrorists, narcotraffickers, and the clan-based, ethnic, or rogue-state support structures within which they exist. Discerning key target sets and determining the effectiveness of our efforts will not be nearly as easy in these cases. In such campaigns, human judgments about the efficacy of bombing will be more important than ever. The idea that humans can be replaced by machines for the purposes of

conducting BDA, a proposal put forward in earnest, as we have seen, by a very senior Air Force officer and echoed by a number of others, is absolutely wrongheaded. It would be as if we were to suggest, in turn, that since weapons are now so accurate, there is no longer any need for manned combat aircraft. A large force of uninhabited aerial combat vehicles (UCAVs), linked to the same master computer database proposed for monitoring BDA, would also allow the computer to monitor the "kills" recorded by each UCAV and keep a running tally. Yet this is a very dangerous fiction. The reality, as we know, is that *there is no substitute for the human intelligence, judgment, and intuition* that pilots bring to an air battle. UAVs and UCAVs provide a useful supplement, but not a replacement. Similarly, there is no substitute for those same qualities among air intelligence officers, nor should we seek to find one. Until we can craft BDA computers and UCAVs intelligent enough to make their own judgments about what to target and the effects achieved, and then to modify their efforts as required, there is simply no substitute for human judgment and intuition in these key warfighting skills. Indeed, we should be profoundly nervous about producing machines with this sort of power to reason.

As we have just mentioned, the nature of our current adversaries also indicates that BDA is more important than ever. We must continue to foster "traditional" BDA capabilities such as those practiced in World War II on the off chance that we will fight North Korea or some other major military power whose armed forces and economy are vulnerable to air attack. At the same time, we must develop the targeting and BDA skills required to conduct effective attacks on terrorists, narcotraffickers, and insurgents. This may involve determining where they maintain "offices" (whether virtual or real) and other administrative structures, where they hide their money and other wealth, the sources

from which they draw this wealth, the means by which they recruit and train adherents, and their leadership and organizational structures. Targeting efforts must determine which of these assets comprise the most vital target sets and how they can most effectively be engaged. *Both the attacks on these targets and the BDA reports produced for them will rely on highly unconventional and cooperative sources and methods* when compared to those employed during the air offensive against Nazi Germany. Attacks may be delivered by computer, by laser, by UCAV, by special-operations teams, and by a variety of other means. The damage assessments produced for these attacks will also rely heavily on the same kinds of unconventional sources and capabilities. Among the most important will be computer-based or signals intelligence-based access to an adversary's plans, personnel rosters, finances, or other assets; special-forces teams providing real-time BDA inputs; friendly indigenous forces working with special operations teams in the same capacity; human intelligence sources; and a new generation of UAVs and UCAVs both tiny and large that can capture the enemy's day-to-day routines, discern his vulnerabilities, and engage him directly with aerial munitions. These UAV and UCAV assets should be centralized within squadrons dedicated to both intelligence, surveillance, and reconnaissance (ISR) roles, and, as required, to direct-action strikes against high-value targets. These units, which we might refer to for purposes of discussion as Combat Assessment, Reconnaissance, and Direct Support (CARDS) squadrons, should have a full range of UAVs and UCAVs at their disposal and be highly integrated into whatever intellectual infrastructures for targeting and BDA are in place within the coming years. These UAVs and UCAVs should also feed real-time data to one another and conduct air strikes based on that exchange of data. Ideally, these multi-echelon UAV squadrons

should contain everything from Global Hawk-like, high-altitude, multi-sensor airframes to micro-miniaturized UAVs with insect flight and hover characteristics and the required sensors to eavesdrop on adversary leadership and operational cells once human intelligence sources and special-operations teams working with indigenous forces or independently have located them. These special-operations teams should also have a complement of small and micro-miniaturized UAVs to employ in their direct-action as well as their observation-and-spotting missions.

This requirement for a new generation of BDA tools brings us to one of the most fundamental “approximate precedents” we can and must draw from the World War II BDA experience and those that followed over the next half century. Put simply, *since the Second World War, the United States has had far too few ISR assets to produce adequate BDA reports, and the problem continues today.* Recent decisions to expand the number of Predator UAV squadrons in the Air Force from three active-duty and two Air National Guard squadrons to as many as 15 squadrons, and to establish a UAV Center of Excellence, are commendable and absolutely vital actions, but the Predator is already a relatively old technology.¹³ We need a much larger selection of UAVs and UCAVs to conduct future ISR, targeting, and BDA functions. The constant and self-defeating struggles among theater (unified) commanders to obtain even *one* additional ISR aircraft and a modest level of satellite coverage during periods of heightened tension speak volumes about this problem. The fact that these high-demand, low-density assets (a term currently in vogue throughout the Department of Defense) inevitably have to come from

¹³ Press Release No. 090305, “The Air Force plans to expand its current Predator initiative,” Secretary of the Air Force, Office of Public Affairs, 18 March 2005; Press Release No. 060305, “Air Force Stands Up UAV Center of Excellence,” Secretary of the Air Force, Office of Public Affairs, 15 March 2005.

another theater commander's assets and thus out of his command's hide, rather than from new production, makes the problem even worse.

A related and equally serious problem is the scarcity of trained targeteers and BDA experts in the Air Force and other Services. The Air Force senior leadership decided over a decade ago to do away with target intelligence officers altogether, arguing instead that all Air Force intelligence officers should be able to pick up the required targeting and BDA skills in short courses and on the job during armed conflicts. This change was in part a response to the abysmal promotion rates for target intelligence officers, whose "over-specialization" in their chosen specialty made them uncompetitive with other officers when their records came before promotion boards. If the World War II experience and those of the intervening sixty years have taught us anything, it is that *targeteers and BDA experts must develop a deep knowledge of their trade, and of enemy target sets, over a period of years.* The Department of Defense has tried to compensate for this major failing by hiring a number of civilian specialists to do this work. The problems with this approach are numerous. First and foremost, civilian employees are unionized, work 40 hours a week, and are by definition much less flexible, deployable, and taskable than their military counterparts. They also have a tendency to remain "outsiders" in the military hierarchy and bureaucracy. Finally, they cannot be required to move from their current billet, even if there are pressing BDA requirements in a different theater of operations. They can make up for this, to a limited extent, by employing "virtual" techniques to work with targeteers and BDA experts from other commands online and interactively, but there are limits here as well. The solution to these problems is once again to train uniformed targeting and BDA experts and then structure the

promotion system in such a way that stability and deep expertise within their specialty become promotable, rather than non-promotable, characteristics. The Air Force officer promotion system, which runs on a one-size-fits-all, up-or-out, philosophy, cannot work in cases such as these, where deep expertise can develop only over a period of years.

Indeed, *air intelligence expertise, and in particular targeting and BDA expertise, is not like that in any other military specialty.* To be at its best, it requires a group of analysts with deep knowledge of potential and current adversaries and their vulnerabilities. Unfortunately, the military's philosophy that all officers should be generalists who work in a number of different jobs over the course of a career, which works well for certain career specialties, works poorly for air intelligence. Put another way, pilots and maintenance officers deal with the same weapon systems and the same general problems wherever they are assigned. Even if they must change weapon systems, the processes and procedures rarely change in any fundamental way. This is absolutely not the case with air intelligence officers. Every theater of operations, every adversary, every target set, is unique and changes over time, meaning that to understand it deeply, air intelligence officers must engage with it over a period of years. In addition, each one of these unique intelligence problems requires unique insights and skills.

This leads us to another truism: *air intelligence is inherently different from ground or naval intelligence; in fact, it is a unique trade requiring unique skill sets, insights, and interactions* with both other military intelligence specialties and civilian experts called on to assist with targeting and BDA functions. This stems from the basic reality we discussed in the introduction: Ground and naval battles tend to occur in a bounded geographic area in which opposing forces grapple with one another directly and each side

knows, in general terms, what the other side has brought to bear. By extension, these sorts of engagements tend to produce clear winners and at the very least give intelligence officers a good idea of what happened. Air campaigns, on the other hand, involve situations in which attacks are followed, of necessity, by the return of aircraft to their air bases. This makes ISR assets vital for determining what happened and whether the effects produced by a series of air attacks has resulted in a high degree of *effectiveness* in terms of achieving both air and overall military objectives. Even with adequate numbers of ISR assets, this is difficult; without them, it is impossible. This means targeting and BDA experts must develop a unique set of skills to help them determine *from afar* what bombing raids have accomplished. Only reconnaissance aircraft and UAVs can do this, and the Air Force has inadequate numbers and varieties of both. (Satellites are also capable of providing BDA, but they are so much less flexible and responsive that it might be best to think of them as ISR assets of last resort for aerospace campaigns.)

Also, because much of the expertise for determining which target sets are most vulnerable, and for assessing the effects and effectiveness of air attacks against them, resides in the civilian sector, the air intelligence community can maximize its effectiveness in the targeting and BDA arenas only if it leverages outside (non-civil servant) civilian talent. This question of civilian talent is absolutely vital. Because our adversaries are for the most part non-state actors, we are in the unenviable position of having to wage open-ended campaigns against them without the benefit of a formal declaration of war, which is the only thing that would make available large numbers of civilian experts with targeting and BDA-related skills. Consequently, *we must leverage civilian talent during peacetime* because we do not have the luxury of drafting it into

service during wartime. This means working with computer networking experts; UAV and UCAV manufacturers; advanced-sensor and advanced flight-characteristics experts; individuals with a deep knowledge of the terrorist, narcotrafficking, and clan-based adversaries we face and their key vulnerabilities; and culturally-focused public-relations and media experts who can assist us in waging effective information campaigns against these adversaries and assessing the damage they do to the enemy's cause. The utter lack of any sort of pro-American or anti-Al Qaeda broadcasts on al-Jazeera is just one example of our failure to cultivate the civilian talent that could allow us to wage the kinds of unconventional aerospace and information campaigns required to defeat these unconventional adversaries. Yet even this will prove ineffective if we do not reshape the organizational structures within which the current BDA process occurs.

The single most important BDA-related lesson from World War II is simply this: *Any BDA effort that proceeds without the benefit of a mature and well-organized intellectual infrastructure will be chaotic and ineffective.* The BDA experience during Operation Desert Storm, in which several competing military commands and civilian intelligence agencies conducted BDA analyses without either sharing their sources or discussing them in any organized fashion, is just one example of the ways in which the lack of a single and well-structured intellectual infrastructure can produce poor BDA or none at all worthy of the name. Indeed, the authors of the *Gulf War Air Power Survey* stated that "Few assertions about the Gulf War could command as much agreement as the inadequacy of bomb damage assessment (BDA), but the Survey found no such agreement

about the causes of inadequacy.”¹⁴ We might perhaps venture to say that *its inadequacy had everything to do with the absence of an intellectual infrastructure like the one that developed during World War II*. All the component parts were in place—technology, technicians, techniques, and capable intelligence agencies—but there had never been any effort in peacetime to integrate and coordinate their activities. The disjointed, duplicative, frustrating, and largely ineffective BDA effort that followed was thus a foregone conclusion. This reminds us again, with great force, just how important it is in this early 21st-century time of undeclared and open-ended armed conflicts, to develop a *standing intellectual infrastructure* with targeting and BDA experts who have the opportunity to spend most or all of their careers studying potential or real adversaries to determine key target sets and vulnerabilities. This simply does not happen within the present air intelligence and national intelligence systems.

These are the BDA-related challenges facing our Air Force and other Services. Additional scholarship on this vital topic cannot but help BDA capabilities, tailored for the 21st century, to improve. In this sense, BDA is a topic well suited as a tool for exploring the development of air intelligence capabilities and their influence on the planning and execution of aerospace campaigns during the 20th and 21st centuries. It is part of a huge field of inquiry—the influence of intelligence on aerospace operations—as yet largely ignored in scholarly literature. It is also a pressing military and national-security issue. American technological, organizational, and campaign-planning prowess will amount to very little in future aerospace campaigns if we do not build a *standing*

¹⁴ Thomas A. Keaney and Eliot A. Cohen, *Gulf War Air Power Survey*, Summary Report (Washington D.C.: U.S. Government Printing Office, 1993), 138.

BDA intellectual infrastructure that incorporates all of these related strengths. This is the challenge facing our Armed Forces today, and it is one that military historians and other scholars can help to meet with additional studies of BDA and its role in future wars.

BIBLIOGRAPHY

Primary Sources

Archival Sources (American)

Library of Congress Manuscript Collection, Washington, D.C.:

Papers of H. H. Arnold

Papers of Ira C. Eaker

Papers of Carl a Spaatz

National Archives and Records Administration, Washington, D.C.:

RG 18 Records of the Army Air Forces

RG 243 Records of the United States Strategic Bombing Survey

Air Force Historical Research Agency, Maxwell AFB, AL:

Records of the Air Corps Tactical School

Records of the Air Service Tactical School

Records of the Allied Air Offensive against Germany

Records of the Army Air Corps

Records of the Chief of Ordnance

Records of the Committee of Operations Analysts

Records of the Eighth Air Force

Records of the Fifteenth Air Force

Records of Mediterranean Allied Air Forces

Records of the Military Intelligence Division

Records of the United States Strategic Air Forces in Europe

Records of the United States Strategic Bombing Survey

United States Air Force Academy Special Collections, USAF Academy, CO:

Manuscript Record 6, Papers of Major General Haywood S. Hansell

Manuscript Record 16, Papers of Brigadier General George C. McDonald

Special Manuscript Collection 190, Papers of Major Donald M. Oenslager

Special Manuscript Collection 347, Papers of Lieutenant Colonel Mark H. Brown

Special Manuscript Collection 376, Papers of Major Martin F. Brown

Archival Sources (British)

The National Archives (formerly the Public Record Office), London:

AIR Air Ministry Records, organized as follows:

AIR 1 Air Historical Branch Records, Series I

AIR 5, Air Historical Branch Records, Series II

AIR 2 Air Ministry Correspondence

AIR 8 Chief of Air Staff Papers

AIR 9 Directorate of Plans

AIR 14 Bomber Command

AIR 20 Unregistered Papers

AIR 34 Central Interpretation Unit

AIR 40 Directorate of Intelligence

AIR 41 Air Historical Branch Narrative Histories

CAB Committee of Imperial Defence Records, organized as follows:

CAB 2 Committee of Imperial Defence

CAB 47 Committee of Imperial Defence, Advisory
Committee on Trade and Blockade in Time of War

CAB 48 Committee of Imperial Defence, Sub-Committee
on Industrial Intelligence in Foreign Countries

CAB 53 Committee of Imperial Defence,
Chiefs of Staff Committee

CAB 54 Committee of Imperial Defence,
Deputy Chiefs of Staff Committee

CAB 55 Committee of Imperial Defence, Joint
Planning Committee

HO Ministry of Home Security Records, organized as follows:

HO 191 Ministry of Home Security, Research and
Experiments Department (RE8)

Published Works (American)

Army Air Forces Air Intelligence School, Photo Intelligence Division. November 1943.
Photo Intelligence for Combat Aviation.

Bradley, Omar N., General, and Air Effects Committee, 12th Army Group. 15 July 1945.
Effect of Air Power on Military Operations: Western Europe.

Chief of Air Service. 1920. *Manual of Aerial Photography (Provisional)*. Washington, D.C.: General Printing Office.

Department of the Army, Historical Division. 1948. *The United States Army in the World War 1917-1919*, Reports of the Commander-in-Chief, A.E.F., Staff Sections and Services, Part II (Vol. 13): (Brigadier General D. E. Nolan, G-2, G.S.), Washington D.C.: U.S. Government Printing Office.

Joint Staff. 14 November 1994. Joint Publication 3-56.1, *Command and Control for Joint Air Operations*. Washington, D.C.: Government Printing Office.

_____. 17 January 2002. Joint Publication 3-60, *Joint Doctrine for Targeting*. Washington, D.C.: Government Printing Office.

USSTAF A-2. 1 August 1945. *The Contribution of Air Power to the Defeat of Germany*.

_____. 8 September 1945. *History of Directorate of Intelligence, United States Strategic Air Forces in Europe, January 1944 – May 1945*.

United States Strategic Bombing Survey (USSBS), Oil Division. January 1947. *Oil Division Final Report*, 2nd ed. Washington, D.C.: Government Printing Office.

_____. Military Analysis Division. November 1945. *The Impact of Allied Air Effort on German Logistics*.

_____. Transportation Division. 20 November 1945. *The Effects of Strategic Bombing on German Transportation*. Washington, D.C.: Government Printing Office.

_____. 30 September 1945. *The United States Strategic Bombing Survey Summary Report (European War)*. Washington, D.C.: Government Printing Office.

_____. 30 September 1945. *The United States Strategic Bombing Survey Over-all Report*. Washington, D.C.: U.S. Government Printing Office.

_____. 30 September 1945. *The United States Strategic Bombing Survey Over-all Report*. Washington, D.C.: Government Printing Office.

_____. 30 September 1945. *Statistical Appendix*. Washington, D.C.: Government Printing Office.

War Department. *Air Corps Field Manual FM 1-40, Intelligence Procedure in Aviation Units (1939-40)*.

_____. Captured Personnel and Material Branch, Military Intelligence Division, 13 December 1944. *Morale and Conditions in the German Army*.

_____. HQ USAAF. March 1944. *Handbook for Combat Air Intelligence Officers*, Second Edition. Harrisburg, PA: Army Air Forces Air Intelligence School.

Published Works (British)

Air Ministry, Air Historical Branch. 1963. *Operational Research in the RAF*. London: Her Majesty's Stationery Office.

_____. *Photographic Reconnaissance*, Part I, 5.

_____. 30 June 1945. *A Photographic Intelligence during the European War*.

_____. 1945. *The RAF in the Bombing Offensive against Germany, Vol. 1, Prewar Evolution of Bomber Command, 1917-1939*.

Admiralty. 1969. *Documents Relating to the Naval Air Service*, 2 vols. London: Her Majesty's Stationery Office.

U.K. 10 November 1932. *Parliamentary Debates (Commons)*, 5th Ser., Vol. 270.

Press Releases (American)

Press Release No. 090305. Secretary of the Air Force, Office of Public Affairs. "The Air Force Plans to Expand its Current Predator Initiative," 18 March 2005.

Press Release No. 060305. Secretary of the Air Force, Office of Public Affairs. "Air Force Stands Up UAV Center of Excellence," 15 March 2005.

Secondary Sources

Published Works

Babington Smith, Constance. 2004. *Evidence in Camera: The Story of Photographic Intelligence in the Second World War*. Phoenix Mill, U.K.: Sutton Publishing Limited.

Barnes, C. H. 1976. *Handley Page Aircraft since 1907*. London: Putnam.

Biddle, Tami Davis. 2002. *Rhetoric and Reality in Air Warfare: The Evolution of British and American Ideas About Strategic Bombing, 1914-1945*. Princeton, NJ: Princeton University Press.

Churchill, Winston. 1985. *The Second World War*. Six Volumes. Boston, MA: Houghton Mifflin Co.

Clausewitz, Carl von. 1989. *On War*. Edited and translated by Michael Howard and Peter Paret. Princeton, NJ: Princeton University Press.

- Cohen, Eliot A. "The Strategy of Innocence? The United States, 1920-1945." In *The Making of Strategy: Rulers, States, and War*, ed. Williamson Murray, MacGregor Knox, and Alvin Bernstein, 428-465. Cambridge University Press, 1994.
- _____. Director. 1993. *Gulf War Air Power Survey*. Five Volumes. Washington D.C.: U.S. Government Printing Office.
- Cooke, Ronald C., and Roy Conyers Nesbit. 1985. *Target: Hitler's Oil*. London: William Kimber, 1985.
- Cooper, Malcolm. 1986. *The Birth of Independent Air Power: British Air Policy in the First World War*. London: Allen and Unwin.
- Crane, Conrad C. 2000. *American Airpower Strategy in Korea 1950-1953*. Lawrence, KS: University Press of Kansas.
- _____. 1993. *Bombs, Cities, and Civilians*. Lawrence, KS: University Press of Kansas.
- Davis, Paul K. 2001. *Effects-Based Operations: A Grand Challenge for the Analytical Community*. Santa Monica, CA: Rand Corporation.
- Deane, John R. 1947. *The Strange Alliance: The Story of Our Efforts at Wartime Co-operation with Russia*. New York: The Viking Press.
- Duffy, Christopher. 1991. *Red Storm on the Reich: the Battle before Berlin*. London: Routledge.
- Faber, Peter R. "Interwar US Army Aviation and the Air Corps Tactical School: Incubators of American Airpower." In *The Paths of Heaven: The Evolution of Airpower Theory*, ed. Phillip S. Meilinger, 183-238. Maxwell AFB, AL: Air University Press, 1997.
- Freniere, Robert W., Colonel, USAF, Commander John Q. Dickmann, USN, Retired, and Commander Jeffrey R. Cares, USNR. "Complexity-Based Targeting: New Sciences Provide Effects." *Air & Space Power Journal*, Spring 2003, Vol. XVII, No. 1: 95-100.
- Garrett, Stephen A. 1993. *Ethics and Airpower in World War II: The British Bombing of German Cities*. New York: St. Martin's Press.
- Geinitz, Christian. "The First Air War Against Noncombatants: Strategic Bombing of German Cities in World War I." In *Great War, Total War: Combat and Mobilization on the Western Front, 1914-1918*, ed. Roger Chickering and Stig Förster, 207-225. Cambridge University Press, 2000.

- Goddard, George, and DeWitt S. Copp. 1969 *Overview: A Life-Long Adventure in Aerial Photography*. New York: Doubleday and Company, Inc.
- Goralski, Robert, and Russell W. Freeburg. 1987. *Oil & War: How the Deadly Struggle For Fuel in WWII Meant Victory or Defeat*. New York: William Morrow and Company, Inc.
- Gordon, Andrew. 1996. *The Rules of the Game: Jutland and British Naval Command*. Annapolis, MD: Naval Institute Press.
- Hansell Jr., Haywood S. 1986. *The Strategic Air War against Germany and Japan: A Memoir*. Washington D.C.: Government Printing Office.
- Harris, Sir Arthur T. 1995. *Despatch on War Operations*. London: Frank Cass.
- _____. 1947. *Bomber Offensive*. New York: The MacMillan Company.
- Hart, Russell A. "Feeding Mars: The Role of Logistics in the German Defeat in Normandy, 1944." *War in History* 1996 3 (4): 418-435.
- Hinsley, F. H., et al. 1979-1990. *British Intelligence in the Second World War*. Five Volumes. London: Her Majesty's Stationery Office.
- Jacob, Margaret. 1988. *The Cultural Meaning of the Scientific Revolution*. New York: Alfred A. Knopf, Inc.
- Jones, Neville. 1987. *The Beginnings of Strategic Air Power: A History of the British Bomber Force, 1923-1939*. London: Frank Cass.
- _____. 1973. *The Origins of Strategic Bombing*. London: William Kimber.
- Kahn, David. 1978. *Hitler's Spies: German Military Intelligence in World War II*. New York: Da Capo Press.
- Keaney, Thomas A., and Eliot A. Cohen. 1993. *Gulf War Air Power Survey, Summary Report*. Washington D.C.: U.S. Government Printing Office.
- Keegan, John. "The View from Kitty Hawk." *Military History Quarterly*, Spring 1998, VIII:3: 6-13.
- Keen, Patricia Fussell. 1996. *Eyes of the Eighth: A Story of the 7th Photographic Reconnaissance Group 1942-1945*. Sun City, AZ: Cavu Publishers.
- Kennett, Lee. 1991. *The First Air War, 1914-1918*. New York: Free Press.

- _____. 1982. *A History of Strategic Bombing*. New York: Free Press.
- Kreis, John F. General Editor. 1996. *Piercing the Fog: Intelligence and Army Air Forces Operations in World War II*. Washington D.C.: Air Force History and Museums Program.
- Lambeth, Benjamin S. 2000. *The Transformation of American Air Power*. Ithaca, NY: Cornell University Press.
- Leaf, Edward. 1997. *Above All Unseen: The Royal Air Force's Photographic Reconnaissance Units, 1939-1945*. Sparkford, UK: Patrick Stephens Limited, 1997.
- Lewin, Ronald. 1978. *Ultra Goes to War*. New York: McGraw Hill.
- Mann, Edward, Colonel, USAF, Retired, Lieutenant Colonel Gary Endersby, USAF, Retired, And Tom Searle. "Dominant Effects: Effects-Based and Joint Operations." *Aerospace Power Journal*, Fall 2001, Vol. XV, No. 3: 92-100.
- Maurer Maurer, ed. 1978. *The U.S. Air Service in World War I*. Four Volumes. Washington D.C.: Office of Air Force History.
- McArthur, Charles W. 1990. *Operations Analysis in the U.S. Army Eighth Air Force in World War II*, History of Mathematics Series, Vol. 4. Providence, RI: American Mathematical Society and London Mathematical Society.
- McFarland, Stephen L. 1995. *America's Pursuit of Precision Bombing, 1910-1945*. Washington D.C.: Smithsonian Institution Press.
- McFarland, Stephen L., and Wesley Phillips Newton. 1991. *To Command the Sky: The Battle for Air Superiority over Germany, 1942-1944*. Washington D.C.: Smithsonian Institution Press.
- McNeill, William. 1982. *The Pursuit of Power: Technology, Armed Force, and Society Since A.D. 1000*. Chicago, IL: University of Chicago Press.
- Megargee, Geoffrey P. 2000. *Inside Hitler's High Command*. Lawrence, KS: University Press of Kansas.
- Meilinger, Phillip S. "The Origins of Effects-Based Operations." *Joint Force Quarterly*, 35 (Summer 2003).

- _____. 1995. *USAF, 10 Propositions Regarding Air Power*. Washington D.C.: Air Force History and Museums Program.
- Michel III, Marshall L. 2002. *The 11 Days of Christmas: America's Last Vietnam Battle*. San Francisco, CA: Encounter Books.
- Middlebrook, Martin, and Chris Everitt. 1996. *The Bomber Command War Diaries: An Operational Reference Book 1939-1945*. Leicester, UK: Midland Publishing.
- Mierzejewski, Alfred C. 1988. *The Collapse of the German War Economy: Allied Air Power and the German National Railway*. Chapel Hill, NC: The University of North Carolina Press.
- Murray, Williamson, Allan R. Millett. 2000. *A War to Be Won*. Cambridge, MA: Belknap Press of Harvard University.
- Murray, Williamson. "The collapse of empire: British strategy, 1919-1945." In *The Making of Strategy: Rulers, States, and War*, ed. Williamson Murray, MacGregor Knox, and Alvin Bernstein, 393-427. Cambridge University Press, 1994.
- _____. 1983. *Strategy for Defeat: The Luftwaffe 1933-1945*. Maxwell AFB, AL: Air University Press, 1983.
- Nesbit, Roy Conyers. 1996. *Eyes of the RAF: A History of Photo-Reconnaissance*. Phoenix Mill, UK: Alan Sutton Publishing Ltd.
- North, Douglass C. North, and Robert Paul Thomas. 1973. *The Rise of the Western World: A New Economic History*. Cambridge: Cambridge University Press.
- Overy, Richard J. "Strategic Bombardment before 1939: Doctrine, Planning, and Operations." In *Case Studies in Strategic Bombardment*, ed. R. Cargill Hall, 11-90. Washington D.C.: Air Force History and Museums Programs, 1998.
- _____. 1995. *Why the Allies Won*. New York: W. W. Norton & Company.
- _____. 1981. *The Air War: 1939-1945*. Briarcliff Manor, NY: Stein and Day.
- Parton, James. March 2000. "Air Force Spoken Here": *General Ira Eaker and the Command of the Air*. Maxwell AFB, AL: Air University Press.
- Phoebus Publishing Co. 1979. *Air Power: A Modern Illustrated History*. New York: Exeter Books.
- Powys-Lybbe, Ursula. 1983. *The Eye of Intelligence*. London: William Kimber.

- Raleigh, Sir W., and H. A. Jones. 1922-1937. *The War in the Air*. Six Volumes. Oxford: Clarendon Press.
- Richards, Denis. 1994. *RAF Bomber Command in the Second World War: The Hardest Victory*. London: Penguin Books.
- Robinson, D. H. 1971. *The Zeppelin in Combat: A History of the German Naval Airship Division*. Sun Valley, CA: John W. Caler Publications.
- Rush, Robert Sterling. 2001. *Hell in Hürtgen Forest: The Ordeal and Triumph of an American Infantry Regiment*. Lawrence, KS: University Press of Kansas.
- Sherman, William C. April 2002. *Air Warfare*. Reprint Edition. Maxwell AFB, AL: Air University Press.
- Sherry, Michael S. 1987. *The Rise of American Air Power: The Creation of Armageddon*. New Haven, CT: Yale University Press.
- Sinnott, Colin. 2001. *The Royal Air Force and Aircraft Design, 1923-1939: Air Staff Operational Requirements*. London: Frank Cass.
- Schaffer, Ronald. 1985. *Wings of Judgment: American Bombing in World War II*. Oxford: Oxford University Press.
- Stanley II, Roy M., Colonel, USAF. 1981. *World War II Photographic Intelligence*. New York: Charles Scribner's Sons.
- Tedder, Lord. 1948. *Air Power in War*. London: Hodder and Stoughton.
- Trevor-Roper, Hugh ed. *Final Entries 1945: The Diaries of Joseph Goebbels*, trans. Richard Barry. New York: G. P. Putnam's Sons, 1978)
- Webster, Sir Charles, and Noble Frankland. 1961. *The Strategic Air Offensive against Germany*. Four Volumes. London: Her Majesty's Stationery Office.
- Weinberg, Gerhard L. 1994. *A World at Arms: A Global History of World War II*. Cambridge: Cambridge University Press, 1994.
- Wells, H. G. 1907. *The War in the Air*. London: Grosset and Dunlap.
- Westermann, Edward. "Hitting the Mark, but Missing the Target: Luftwaffe Deception Operations, 1939-1945." *War in History*, April 2003, 10 (2): 206-221.
- Williams, George K. 1999. *Biplanes and Bombsights: British Bombing in World War I*. Maxwell AFB, AL: Air University Press.

_____. "The Shank of the Drill": Americans and Strategical Aviation in the Great War." *The Journal of Strategic Studies* 19:3 (September 1996): 381-431.

Ziemke, Earle. 1968. *Stalingrad to Berlin: The German Defeat in the East*. Washington, D.C.: Office of the Chief of Military History, United States Army.

Zuckerman, Solly. 1978. *From Apes to Warlords*. New York: Harper & Row, 1978.

Unpublished Works

Guilmartin, Jr., John F. "The Aircraft that Decided World War II: Aeronautical Engineering and Grand Strategy, 1933-1945, The American Dimension." Expanded version of work presented as the Harmon Memorial Lecture, USAF Academy, 2001.

Milutinovic, Aleksandar. "First Foray: The United States Army Air Forces' Strategic Strike at Ploesti, 1 August, 1943." M.A. Thesis, The Ohio State University, 2001.

Newspaper and Magazine Articles

Galbraith, John Kenneth. "Peace through Patience, Not Air Power." *The New York Times*, 25 April 1999.

Moseley, T. Michael, General, USAF. "BDA Fades Away." *Air Force Magazine*, August 2004: 9-10.

Priest, Dana. "The Commanders' War: The Plan to Invade Kosovo, A Decisive Battle that Never Was." *The Washington Post*, 19 September 1999.